ANTITRUST VS. COOPERATIVE RESEARCH

IS THE SOFTWARE FOR STAR WARS IMPOSSIBLE? ▪ REUSING WASTE OIL

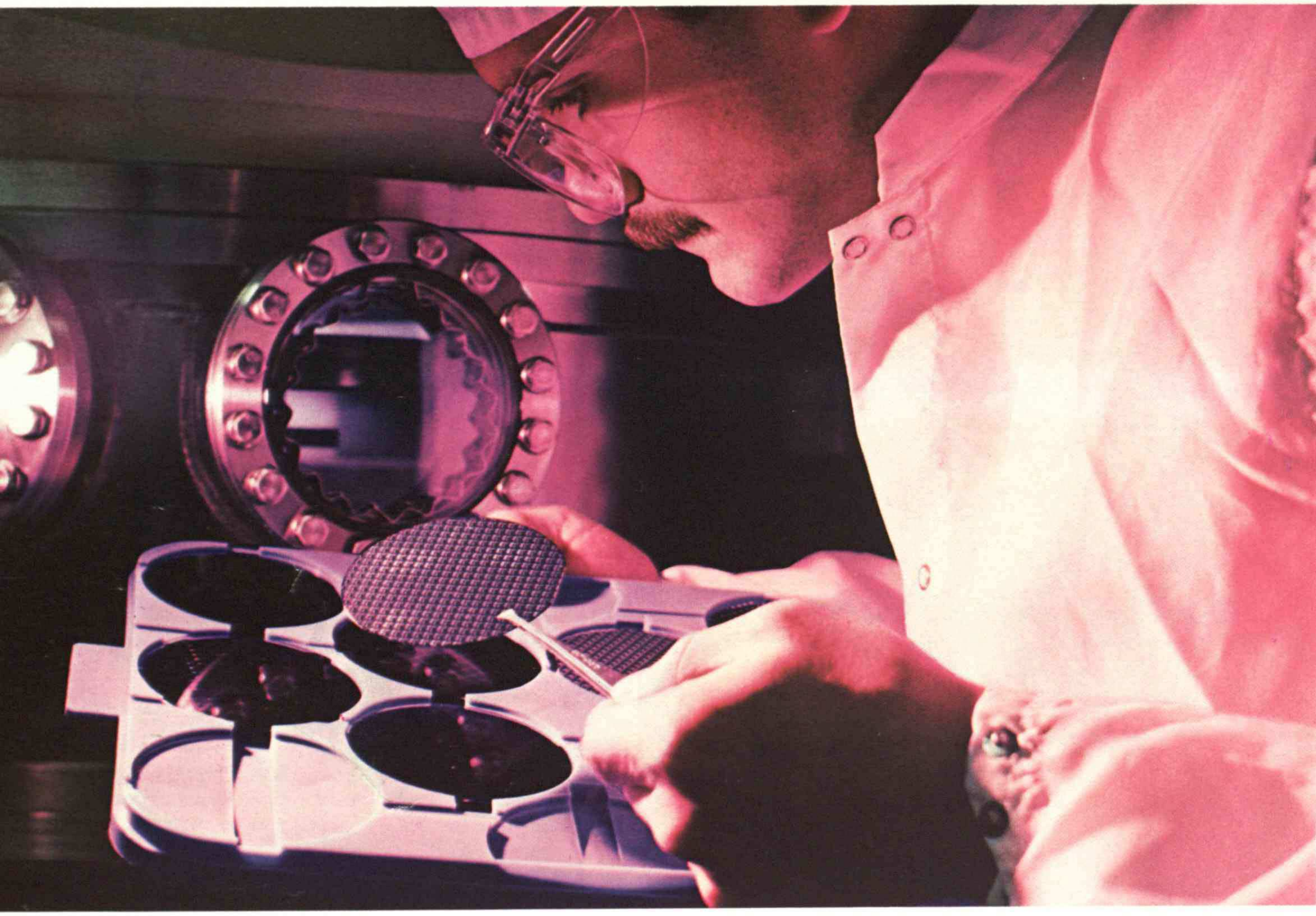
Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY JULY 1985 $3.00

FALSE HOPES, REAL PROMISE

THE CHALLENGE TO RESTORE PARALYZED LIMBS

A proving ground for computers.



Nobody makes more automotive computers than General Motors.

No other automotive company subjects their computers to more torture tests. 40 degrees below zero to 185 above. Electron microscope scanning. Moisture. Vibration. Testing that equals 10 years of typical driving.

Our computerization gives you improved driveability. Smooth performance regardless of speed. An indoor climate control system. And greater fuel economy.

And the reliability of our computers makes the operation of your new GM car or truck safer and more efficient.

We believe in taking the extra time, giving the extra effort and paying attention to every detail. That's what it takes to provide the quality that leads more people to buy GM cars and trucks than any other kind.

That's the GM commitment to excellence.

GM

Nobody sweats the details like GM.

Chevrolet • Pontiac • Oldsmobile • Buick • Cadillac • GMC Truck

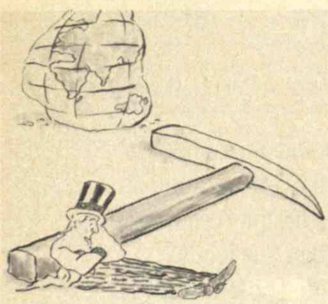
JULY 1985 VOL. 88 NO. 5

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

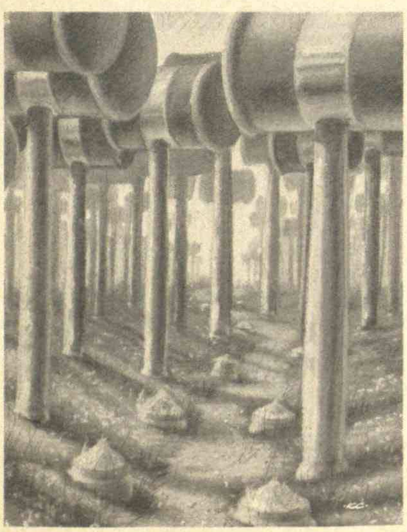
TechnologyReview

54

46



30



38

COVER
Illustration by A. Hardy Roberts
Design by Nancy Cahners

Rooms²

This fall, discover a new formula for traveling in comfort and style, when Boston's first—and only—all-suites hotel opens on the picturesque Charles River. Everyone gets a deluxe 2-room suite overlooking our sweeping 15-story atrium. With separate living room, refrigerator, wet bar, sofa bed, 2 color TVs and cozy dining area. All for the price of a single room in any other first-class hotel.

What's more, every guest gets a free full breakfast, 2-hr. private Manager's Cocktail Reception and ample free parking, with courtesy transportation.

The hotel has a bright, comfortable lounge with piano bar. A splendid restaurant serving the finest in regional American cuisine. Plus an indoor swimming pool, whirlpool and sauna. Increase your travel pleasure, geometrically. Try the new Embassy Suites Hotel. Call now for reservations: **1-800-EMBASSY, or (617) 783-0090.**

EMBASSY SUITES℠ HOTEL

400 Soldiers Field Road, Boston, MA 02134 • (617) 783-0090

Operated by Beacon Hospitality Group under license by Embassy Suites, Inc.

Also open in Valley Forge, PA and at Philadelphia International Airport.

TechnologyReview

PUBLISHER
William J. Hecht
EDITOR-IN-CHIEF
John I. Mattill
MANAGING EDITOR
Peter Gwynne
DESIGN DIRECTOR
Nancy L. Cahners
DESIGN/
PRODUCTION MANAGER
Kathleen B. Sayre
SENIOR EDITORS
Alison Bass
Tom Burroughs
Sandra Hackman
Sandra Knight
Susan Lewis
Jonathan Schlefer
PRODUCTION/EDITORIAL
ASSISTANTS
Elizabeth Fullon
Valerie Kiviat

BUSINESS MANAGER
Peter D. Gellatly
CIRCULATION DIRECTOR
Julie Zuckman
SUBSCRIPTION SERVICE MANAGER
Dorothy R. Finnerty
CIRCULATION/ADVERTISING
ASSISTANT
Deborah Gallagher

Technology Review (ISSN 0040-1692), Reg. U.S. Patent Office, is published eight times each year (January, February/March, April, May/June, July, August/September, October and November/December) at the Massachusetts Institute of Technology. Entire contents © 1985 by the Alumni Association of M.I.T. Printed by Lane Press, Burlington, Vt. Second-class postage paid at Boston, Mass. and additional mailing offices. Postmaster: send address change to M.I.T., Room 10-140, Cambridge, Mass. 02139.

Editorial, circulation, and advertising offices: *Technology Review*, Room 10-140, Mass. Institute of Technology, Cambridge, Mass. 02139 (617) 253-8250.

Advertising representatives:
The Leadership Network: 254 Fifth Ave., New York, N.Y. 10001 (212) 684-5500; Benson Co., Park Ridge, Ill.; Colin Smith Agency, Berkeley, Calif.; Joe DeLone & Associates, Wayne, Pa., Fairfield, Conn., Lincoln, Mass.; J. J. Arcisz Co., Boston, Mass.; and McKeldin Co., Atlanta, Ga.
Littel-Murray-Barnhill, 1328 Broadway, New York, N.Y. 10001 (212) 736-1119.

Subscription inquiries and change of address: Room 10-140, M.I.T., Cambridge, Mass. 02139 (617) 253-8292.

Prices:
Subscriptions, one year: libraries and organizations \$27; all others \$24. Canada add \$6; other foreign countries add \$12. Single copies and back issues available. All prices U.S. funds.
U.S.A. newsstand distribution by Eastern News Distributors, Inc., 1130 Cleveland Rd., Sandusky, Ohio 44870, 800-221-3148.

Award Time

Nomination for a National Magazine Award, administered by the Columbia Journalism School, brought high elation and a photographer to record the faces that go with our masthead. Counterclockwise from the foreground: Fullon, Lewis, Gallagher, Bass, Finnerty, Kiviat, Cahners, Gwynne, Knight, Zuckman, Mattill, Schlefer, Hackman, Sayre, and Burroughs.

Magazines come in every size and style and for every purpose, unified only by their physical dimensions and in their determination to serve their readers' needs and the public interest. Hence the dilemmas that must confront those who set out, each year, to judge this nation's thousands of magazines: they must determine which in fact is the "best" in a genre that includes *Foreign Affairs* and *The Georgia Review*, *American Heritage* and *The New Yorker*.

We're gratified to report that *Technology Review* emerged from such a complex and almost imponderable judging process among the six nominated in the "public service" category for a 1985 National Magazine Award. These awards are the "Oscars" of the magazine business, administered by the Columbia School of Journalism for the American Society of Magazine Editors. The nomination was for "The Not-So-Clean Business of Making Chips" (*May/June 1984, page 22*) by Professor Joseph LaDou of the University of California at San Francisco, with additional reporting by Alison Bass, senior editor . . . coverage that the judges deemed to have "a demonstrable impact on an area involving the public interest." The nomination is the first for *Technology Review*; we share our pride with readers and send our thanks to Dr. LaDou; and we send our congratulations to *The Washingtonian* as the final winner.

Another major award also came to us this spring: the frontispiece illustration for "Antisatellite Weapons: The Present Danger" (*August/September 1984, page 54*) by Kosta Tsipis and Eric Raiten received a silver medal in the 1985 exhibition of the Art Directors Club of New York, the country's largest (17,000 entries) and most prestigious juried graphics exhibition. It was artist Rob Colvin's first published illustration, and thus the award speaks not only to the artist's success but also to our designers' ability to pick up-and-coming newcomers. More kudos for our designers and illustrators, too: ten design/illustration entries from *Technology Review* were accepted for the annual juried show of the Boston Art Directors Club.

Magazines are by definition perishable, and these awards are for issues of the *Review* that have lost the cutting edge of newness. While they nurture our egos, we know that they also make last year's issues a hard act to follow—a challenge that we accept with pleasure and confidence.—*John Mattill*

PHOTO: J. J. MARTORI

Women in Technology

As a woman, I found your articles on women's gains (and the lack thereof) in upper levels of science and technology interesting reading (*November/December*). I have found that similar roadblocks exist for women in industry. The barriers are subtle, but nevertheless they interfere with women's ability to advance in their chosen careers. The law may have forced companies to allow women through the plant gates, but it has not brought them equal opportunity once inside.

My first job was with a Fortune 500 firm with an excellent reputation for fairness and good employee relations. My supervisors seemed pleased to have recruited a bright, young, aggressive women. But I soon found out how young, aggressive women were treated in my department: my ideas were made to appear so bad that my supervisor and male coworkers didn't even have to listen to them. However, if these same coworkers made a suggestion similar to mine, it was often lauded. I quickly learned to avoid offering suggestions, or to make them through a coworker. Thus, my efforts were hidden from my supervisor and my career was stifled.

I strongly believe that universities such as M.I.T., which spend a lot of time, effort, and money on educating women, should help their alumni deal with these inequities. Making it easier for women to reach their full potential is in the universities' best interests. And as each male science and engineering student will one day become some woman's coworker, supervisor, professor, husband, or father, programs that help break down stereotypes are helpful to everyone.

Janet Metsa
Durham, N.C.

Having been a faculty member in the Department of Geology at Carleton College throughout the 1970s, I consider Lilli Hornig's statment about the college's geology program during that period outrageous at worst, and untrue at least. (*See "Women in Science and Engineering: Why so Few?" in November/December, page 35.*) The fact is that during that decade, we graduated 64 women in a total of 149 geology majors—an average of 42.2 percent. Since 1980, the percentage of female geology majors here has averaged 44 percent. There are twice-a-year week-long field trips open to *all* geology students; there never has been a senior field trip such as Ms. Hornig suggests.

A study of the statistics on geology enrollments compiled by the American Geological Institute (AGI) indicates that few other schools of comparable size and curriculum have graduated as many women geologists as Carleton. Indeed, we are one of the most important sources of women geoscientists in the country, regardless of school size.

The pertinent question is whether women perceived geology to be a career option, and whether we discriminated against women "subtly." Between 1974 and 1979, we educated 1.18 percent of the nation's female geologists. Approximately 4 percent of all women who graduated from Carleton during the 1970s were geology majors. During the same period, the geology faculty was about 2 percent of the total college faculty. If Ms. Hornig had truly been perceptive about these issues, she would have cited Carleton as a leader in overcoming the subtle forms of sex discrimination she wished to illustrate.

Edward Buchwald
Northfield, Minn.

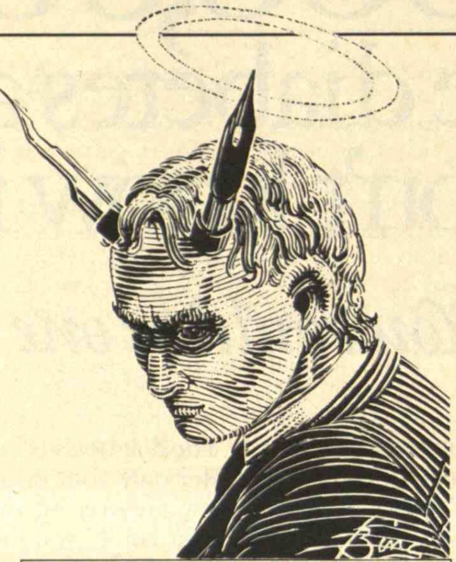
Edward Buchwald is chairman of the Department of Geology and Lloyd McBride Professor of Environmental Studies at Carleton College.

There is something deeply disturbing about seeing the G.I. Bill described as "a blow for women" and "a palliative to almost certain unemployment and social unrest after World War II." No doubt there is truth in the various figures cited to support the view that women have suffered certain handicaps in obtaining desirable positions in science and engineering as a result of the G.I. Bill. But there is no sense of balance in the argument. Those who fought in the war lost years in career development and reduced earning potential. Some suffered permanent physical or mental disability from the horrors of war. Some gave their lives. Those who served participated in a grim lottery, often without any real choice.

If a war has to be fought and social justice must be maintained, there are only two options: to draft everyone into service and subject them all to the same risks, or to draft no one but offer high rewards to attract enough volunteer personnel. The second option would not have worked during World War II. Conscription was deemed the necessary solution, but it was

Continued on page 18

Science Writers: Angels or Devils?



Newfangled media manipulation and old-fashioned competition can distort the reporting of complex technical issues.

It's tough being a science writer these days. No sooner had I dived under the table to escape the barbs of presidential science advisor George A. Keyworth II than I bumped my head trying to emerge and take a bow at the biotechnology symposium of the National Academies of Science and Engineering.

In remarks widely quoted last winter, Keyworth criticized the press for negativism and doing "an irresponsible job of discussing important technical issues . . . the role of biotechnology, for example." Shades of Spiro Agnew's nattering nabobs of negativity! Yet at the academies' symposium the press was hailed as the essential catalyst for improving public understanding of these very issues.

So which is it: devil, angel, or a little bit of both? If science reporting is really as bad as Keyworth suggested, how can it be a medium of enlightenment as the syposium speakers maintained? Or is genuine enlightenment really what they have in mind? Two independent studies have thrown some interesting and disturbing light on such questions.

A three-year study based on interviews with editors and reporters convinced Jay Winston of the Harvard University School of Public Health that the prime cause of distorted science reporting isn't ignorance, bias, or deadline pressure. It's old-fashioned competition for the front page and a spot on the evening TV news. Many reporters admitted to hyping their stories and distorting facts to gain prominent display. Editors acknowledged that they pressure writers for more color and bite than some stories warrant. The result, Winston told the *Harvard Gazette*, is that "the intense competition places reporters in a conflict-of-interest situation where the reporter's personal aims can be at odds with providing a balanced presentation."

Keyworth, on the other hand, blamed distortion on what he perceived as the press's desire to gain power "by being negative and tearing at [established] foundations." He observed that "much of the press seems to be drawn from a relatively narrow fringe element on the far left of our society." That sounds like the cry of a frustrated critic who doesn't like reporting that presents things in what he considers the "wrong light." His allegation is a myth. But to me, as a press insider, Winston's findings have the ring of truth.

The flip side of Winston's conclusion is what he calls the "current public-relations blitz." Some experts, environmentalists, and other special-interest pleaders present out-of-focus views of technical issues—the risks of nuclear power or the hazards of acid rain, for example. Some scientists blatantly seek publicity for their work. And naive reporters blithely echo these self-serving pronouncements.

It's the shower of self-serving press releases from academe and industry that really fogs the lens of objectivity. Cornell University sociologist Dorothy Nelkin says she finds that "the press is viewed by all interests as a resource through which to manipulate the public." Worse, she also found in a study of environmental reporting "that half of the published stories adopted the language as well as the content of press releases."

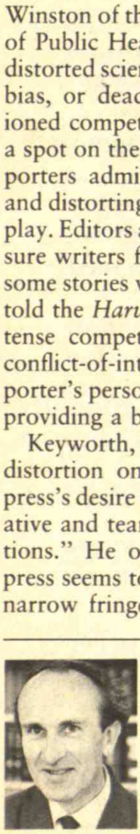
What an indictment of supposedly tough-minded editors and reporters! In their defense, I should say that it's hard to keep one's perspective amid this Machiavellian clamor. Some science writers told Winston that they receive 400 pieces of mail a week. A spot check of my own mail showed that 75 pieces had arrived between the close of business on a Friday afternoon and the reopening the following Monday. About 80 percent consisted of the manipulative messages to which Nelkin and Winston refer. Most were of dubious value.

In addition, a new, high-pressure practice has grown up among public-relations agencies that some of us find repugnant. It's the so-called "follow-up" phone call. Often I haven't even opened the mail when a call comes in asking if I have such and such a release and what I intend to do about it. This is thinly disguised harassment, as some of the callers have admitted under questioning.

Trying to report complex, often controversial, scientific and technological issues with balance, perception, and objectivity in such an atmosphere is a little like trying to write poetry in an iron foundry. Add to this the temptation to play up "a good story" in the competition for display, and you get much closer to the reason that science reporting is sometimes distorted than do Keyworth's dark suspicions.

The press itself has to answer for its faults, which include an embarrassingly high level of naïveté not generally found in political reporting. But with all those manipulators out there in laboratory clothing, it isn't easy for even the seasoned science writer to avoid all the pitfalls.

I agree with Keyworth and many other critics of science writing that there is too much distortion in science reporting—along with much excellence. But there is no simple remedy. Editors and reporters need to bring to their sci/tech coverage the tougher standards they apply to political reporting—as they already do in many cases. But their critics in industry, government, and academe also need to clean up their act. Their "disdain" (to use Keyworth's word) for the press belies their professed sincerity in wanting to inform the public. And please, would those who channel their manipulative messages through public relations firms ask that queries about press releases be made after midnight and before 4 A.M.? The guard on duty in our building will be happy to take the messages. □



ROBERT C. COWEN IS SCIENCE EDITOR OF THE CHRISTIAN SCIENCE MONITOR *AND FORMER PRESIDENT OF THE NATIONAL ASSOCIATION OF SCIENCE WRITERS.*

ILLUSTRATION: CHRISTOPHER BING

SCIENCE/SCOPE

A new radar can map military targets with high resolution equal to that of infrared devices, even in rain and other bad weather. The Advanced Synthetic Aperture Radar System (ASARS-2), designed to complement electro-optic sensors, is flown on a U.S. Air Force TR-1 reconnaissance aircraft and provides real-time radar imagery to a ground station. ASARS-2 operates in all weather at ranges far exceeding the capabilities of infrared and other electro-optic devices, thanks to new state-of-the-art signal processing and other advances. The Air Force gave the system an excellent rating after it underwent strict operational performance tests as part of a "fly-before-buy" program. Hughes Aircraft Company is producing the system under a development and production contract. Eventually ASARS-2 is expected to be adapted for tactical aircraft and mobile tactical stations.

Jam-resistant communications have been introduced into NATO by a new terminal for AWACS early-warning aircraft. The Joint Tactical Information Distribution System (JTIDS) Class 1 terminal is designed to combat the formidable and growing electronic countermeasures threat to tactical communications. JTIDS uses principles of time division multiple access to provide secure, high-capacity communications for AWACS radar planes and ground stations. The system relays a wide variety of information, such as command and control, surveillance, intelligence, force status, target assignments, warnings and alerts, weather, and logistics. Software filtering lets each participant select data pertinent to his own needs. Hughes is producing the JTIDS terminal for use with NATO's Airborne Early Warning/Ground Environment Integration Segment (AEGIS).

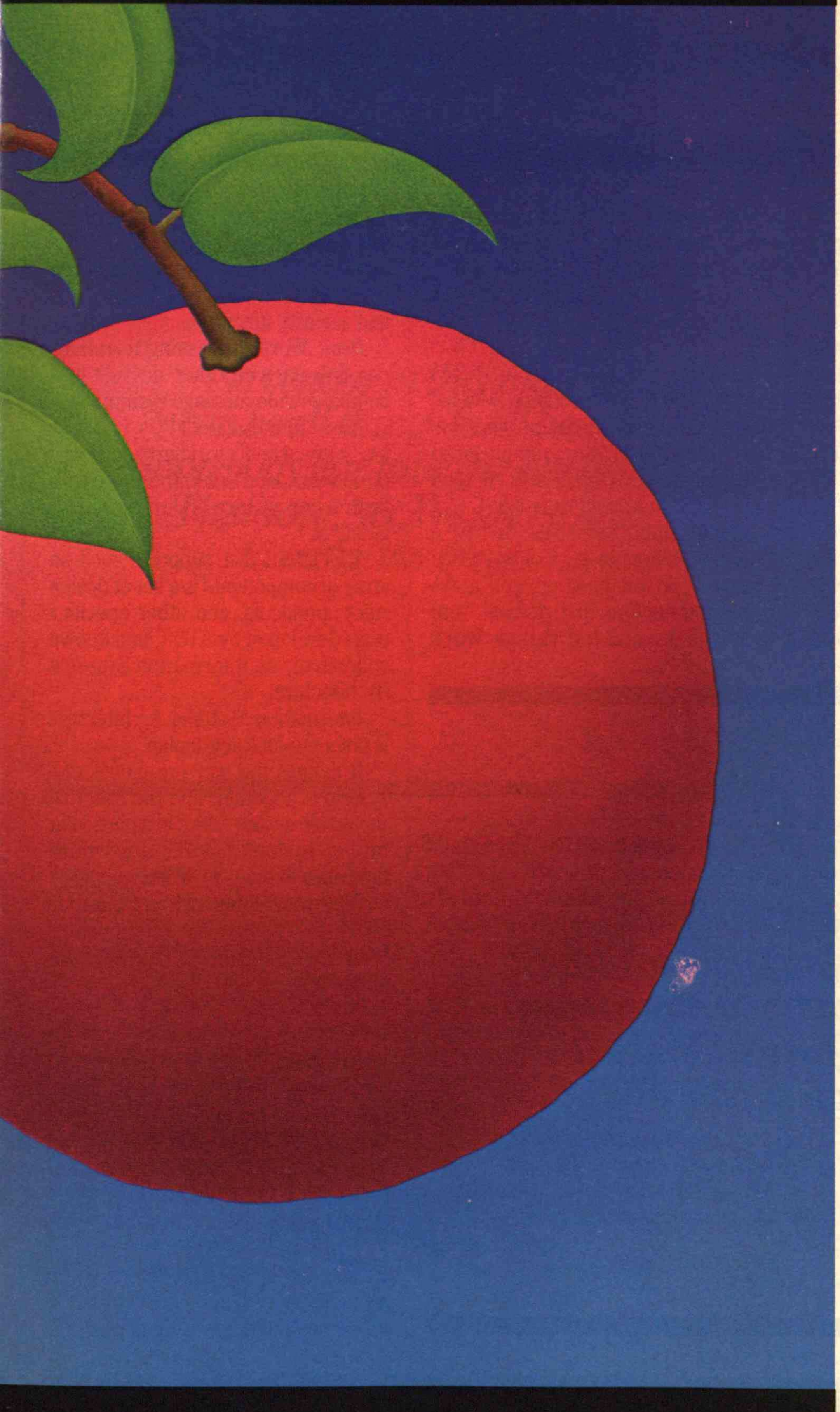
Lasers soon will be inspecting solder joints of fighter aircraft radars, thanks to new manufacturing technology being set in place at Hughes. Solder joints will be examined by a computerized technique using lasers and fiber optics, the glass threads that carry laser light transmissions. The process will free manufacturing personnel from tedious and time-consuming inspections of more than 36 million solder joints created in a single year's production. The project is part of an Industrial Modernization Incentive Program (IMIP) awarded by the U.S. Navy and Air Force. IMIP is a share-the-savings concept that will reduce costs of the F-14, F-15, and F/A-18 radar programs by more than $10 million, while improving the quality and reliability of the systems.

Two high-power direct-broadcast satellites will carry family-oriented and religious programming for Dominion Video Satellite, Inc. The Hughes satellites will incorporate a novel design, combining existing technologies of spin-stabilized satellites and body-stabilized satellites. Each will carry large, winglike solar arrays similar to those on body-stabilized satellites. The wings will extend 110 feet, generating 5,000 watts of electrical power for eight channels of communications. A central spinning section will provide gyroscopic stability and additional electrical power for basic housekeeping functions. The satellites will be equipped with batteries to provide full power when the spacecraft pass through Earth's shadow and the sun is blocked from the solar cells.

Hughes' Santa Barbara Research Center is seeking experienced engineers and scientists to further develop advanced IR focal plane technologies. We need custom integrated circuit designers, nuclear effects engineers, material scientists, semiconductor device scientists and process engineers, and IR system analysts. To learn how to become involved in this innovative technology, contact the Santa Barbara Research Center, Professional Employment, Dept. S2, 75 Coromar Drive, Goleta, CA 93117. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 11205, Dept. 70-12, Marina del Rey, CA 90295

HUGHES
AIRCRAFT COMPANY



THE RACE FOR A UNIVERSAL OFFICE SYSTEM

The sales pitch goes like this: In the "Office of the Future" everything will work together – computers, telephones, word processors, the works. The new *integrated* systems, they say, will even turn out the lights when you go home.

Behind these seductive promises are some of the most capable companies in America: IBM, Wang, AT&T, and a host of scrappy newcomers.

Each has established a beachhead in the "Battle of the Desk Top." Each aims to extend its reach into more of your office. And that is why so many business people have cried "Whoa!"

Too often, "systems integration" turns out to mean buying more of a

continued on next page

continued from preceding page

particular vendor's products. At the core of some proposals is an open-ended commitment to a single supplier.

Few customers are eager to make such a marriage. Most are still sorting out the office of the present; they want to integrate the systems they already have.

Says one technology-watcher: "Customers are used to going to different vendors for different needs. Now they're being asked to buy everything from everybody."

Enter AT&T Information Systems with an unusual perspective: AT&T itself is among the largest *users* of computers and communications gear in the world.

We know what can go right – and what can go wrong. It is this *experience* that is at the heart of the systems integration plan we now offer to our own business customers.

◇

SHOTGUN. AT&T Information Systems believes that an integrated office system shouldn't involve junking products you already own. Nor a shotgun wedding with a single supplier.

As customers ourselves, we have a huge investment in our existing office systems. So we have created a systems architecture that defines "integration" as making things work together – whether they're old or new, our own or somebody else's.

Item: Your office telephone system can do double and triple duty as a highway for data – supporting computer traffic, monitoring energy use and security functions.

Item: Word-processing terminals can link up with other devices in a company-wide message system.

Item: Your isolated PCs can now be "networked" to share data and peripherals, and to communicate with larger computers. (Our own, and Brand X.)

The fabric that supports such an array of components is a set of design rules, protocols, and other specifications developed by AT&T, and known collectively as Information Systems Architecture.

Information Systems Architecture is not a product; it is a plan.

It defines the way the pieces of a system fit together, and the role that the whole system plays in a particular office. It does not dictate whose machines to buy – or when.

Like your company's organization chart, it outlines the relationships between "departments," but does not create policy itself.

◇

WHO'S WHO. A couple of months ago, we showed this ad to some technical experts from outside AT&T. "Where's the beef?" they asked. "Whose gear can you tie together *exactly?*" they asked. "How well *exactly?* What next... *exactly?*"

The kind of detail our technical friends had in mind would leave the average reader numb. The items that follow are rated G – suitable for the

> *"An integrated office system shouldn't have to mean junking products you already own. Nor a shotgun wedding with a single supplier."*

No vendor in this market can be all things to all people. Somebody has to be the Integrator. That's our Ace. We know how to make the pieces fit.

general business audience:

Open house. For a token $500, AT&T will show any competitor how to link their products with our digital switching systems. (*PBX*s, to the trade.) The names in our guest book read like a vendor's *Who's Who*: Wang, Mitel, Hewlett-Packard, Prime, Data General, NEC and 40 others.

Result: a better fit between their office automation gear and our PBXs...and thus better communication between the products of warring vendors. In your office, at least, they become allies.

This "instant network" welcomes change. New terminals click right in to little outlets that look suspiciously like your phone jacks at home. Pinch, click! and your people are off to the races. They can share data, mail each other electronic valentines, make more money for the firm.

Good news for IBM customers. A number of companies have found that an AT&T environment can enhance the usefulness of IBM equipment by serving as a "bridge" between Big Blue and the rest of the business world.

Folding IBM's unique system into a more open, more universal scheme is a tall order. Today's customer must install special "black boxes" to act as intermediaries.

We can't say what IBM's troops are up to, but many of AT&T's best and brightest are working nights to make the AT&T-IBM connection simpler, cheaper, and more complete. We will keep you posted on our progress.

◇

AVALANCHE. On a typical business day, the assembly lines and "clean rooms" of AT&T will roll out thousands of computers, PBXs, printers, modems, terminals, networks and software.

In 1984 we launched 100 new products, twice as many as the year before. Despite this avalanche of systems, it is our belief that no vendor in this market can be all things to all people.

Somebody has to be the Integrator. That's our Ace. We know how to make the pieces fit.

In AT&T Information Systems Architecture, we now have the means to integrate office machines from many sources – ourselves and others, new or installed — into a single system.

A *system of systems* that fits each customer's particular business needs.

To learn how Information Systems Architecture applies to your company's present and future plans, please telephone 1-800-247-1212. Or write Mr. Dale Hegstrom, AT&T Information Systems. P.O. Box 1405, Morristown, NJ 07960-1405.

AT&T

The right choice.

Preventing the Next Bank Panic

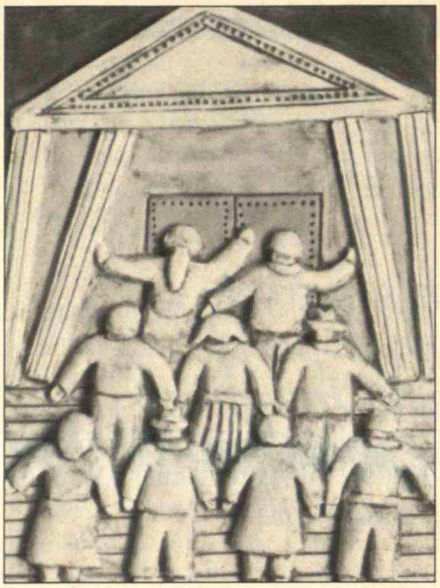
TIMES are tough on the predictions of economists. Last summer, while working on an article for the *New York Times* on the Continental Illinois Bank crisis, the art editor asked me where she could obtain pictures of people sleeping in the streets waiting to get their money out of the banking system. I confidently told her that she was hopelessly out of date. We would never again see people sleeping in the streets because they were worried about small deposits. Small deposits were insured. In the 1980s, banking crises take the form of a telex from big money-market managers withdrawing billions of dollars in uninsured deposits.

How wrong I was. Within nine months, people were sleeping in the streets in Ohio, anxious to get their money out of local banks. And they had cause to be worried. Many of them lost the use of their money for several days or weeks, and a few small depositors may lose some of their money permanently because the state insurance fund is also broke.

By now no one can doubt that the American banking system is fragile. Deposits, whether large or small, are no longer completely secure, and the American public has a right to be nervous. When one asks why a seemingly stable banking system has suddenly become unstable, the answer comes in two parts: technology and theology.

Many of the banking laws designed to protect bank depositors have been made obsolete by technology. The telephone, telex, and computer have undercut the laws prohibiting interstate banking and limiting financial institutions to certain types of activities. One can now do business in a state without physically being in that state. For instance, someone with an automatic teller card from a bank in New England can use that card to retrieve money in New York because of arrangements banks in different states have made with one another.

Thanks to modern communications technology, large financial institutions such as Sears and Merrill Lynch can offer customers in many states money-market accounts and other services traditionally offered by local banks. And since these large institutions do a higher volume of business, they often can provide lower interest rates and better services than smaller banks not tied into similar communications networks.



New technology and today's free-market theology are eroding the stability of our banking system.

Technology has thus made possible completely new kinds of banking arrangements. But there is another force at work here. In a previous era, laws would be passed to regulate these new arrangements if and when abuses became apparent. For instance, after the stock market crash of 1929 and the bank failures of the 1930s, a whole set of financial regulations was adopted. These regulations were designed to guarantee depositors that they could safely park their money without worry. Federal audits guaranteed (theoretically) that banking institutions were honest, and other laws guaranteed that the federal government would fully insure deposits (up to $100,000).

However, those guarantees of honesty and safety have started to unravel. After 55 years, it seems, everyone who was old enough to have really experienced the Great Depression is dead or beyond influencing the rest of us. And society is once again ignorant enough to repeat its early mistakes.

A theology based on the virtues of the free markets now prevails. Anyone who believes in those virtues thinks the free market can do no wrong and is therefore opposed to bank regulations. If regulators do not believe in regulation, then as a practical matter, regulations gradually cease to exist—even if the laws behind them do not change.

President Reagan's regulators have made no effort to regulate the new kinds of banking that have developed because of advances in communications technology. Consider the buying and selling of government bonds. Big banks have always bought and sold government bonds, but they do so within the safety of their own subsidiaries. Small banks are also getting into that business. The competition from interstate and multifunction banking has forced them to become "go-go" banks if they wish to remain financially independent and avoid takeover bids. And many have gone after the government bond market—even though they do not always have the human skills necessary to play in that market aggressively.

Because of their size and out-of-the way location, small banks are often forced to do business with government bond dealers they do not know and cannot control. However, the audit regulations that were passed in the 1930s do not specifically cover these external bond dealers because they did not exist at the time. In an earlier era, the law would have been broadened to subject them to audit, but in the Reagan era of "let free markets rip," this hasn't happened.

In Florida, one such bond dealer, who happened to be fudging his books, went broke and brought one of its Ohio bank lenders down with it. The losses of the Home State Savings Bank in Cincinnati were large enough to bankrupt the entire Ohio bank insurance system. When the Ohio bank insurance system goes broke, member banks who have not lent money to the Florida bond dealer are also forced to close their doors.

Even though the Ohio banks were not technically insured by the federal government, in an earlier era federal regulators

LESTER C. THUROW IS GORDON Y BILLIARD PROFESSOR OF MANAGEMENT AND ECONOMICS AT THE SLOAN SCHOOL OF MANAGEMENT AT M.I.T.

ILLUSTRATION: KEN GOLDSTROM

would have immediately intervened to protect the depositors. They would have worried about collecting the necessary revenue from the state of Ohio or its state-insured banks only after making sure the system was stable. But in the Reagan era, regulators stood aside and let state authorities wrestle with a problem they could not quickly solve.

Panic soon set in among small depositors, and for a few weeks the entire state-insured banking system in Ohio ground to a halt. Most of the banks eventually reopened and the crisis was alleviated, but not before another element of risk and uncertainty had been added to the American banking system. Each such element makes our system less stable and more fragile. Unregulated free financial markets are unstable and always have been unstable. That is the repeated lesson of history, and those who refuse to learn the lessons of history are doomed to repeat them.

Protecting Depositors Large and Small

Big banks are no more immune to this history lesson than small ones. Take, for example, the recent collapse of Penn Square Bank in Oklahoma. Technically, government insurance protects only small depositors; only the first $100,000 in deposits is insured. In fact, the federal government has been following a policy of protecting all depositors, large and small, since the Great Depression. When banks have gone broke, no one, large or small, has been allowed to lose money. But when the Penn Square went broke a few years ago because of large losses on its portfolio of energy loans, its large depositors were not protected; they lost their deposits over $100,000.

The free marketers running the Federal Deposit Insurance Corp. (FDIC) believed that if the large depositors were forced to lose money, they would take over the FDIC's function of policing the banking system. Large depositors would watch the books of the banks where they were making deposits, and if these banks started to make dangerous loans, the larger depositors would begin to withdraw their money, forcing the banks to adopt more conservative lending policies. In this way, the FDIC reasoned, the banking system could operate without federal regulation and inspection.

The problem is that large depositors do not want to police the banking system; they have better things to do with their time and money. And they could not be the policing agent even if they wanted to, because they do not have legal access to the books of both the banks and their customers. Large depositors simply want safety and will flee any institution where they feel unsafe.

The failure of Continental Illinois, the country's eighth largest bank, is another case in point. True, Continental Illinois had made some bad loans, many to the Penn Square Bank. But it was not broke, despite rumors to that effect. The rumors began in the Far East and caused some big, supposedly sophisticated depositors to panic and withdraw billions of dollars from Continental Illinois.

The rumors then spread to Manufacturers Hanover and withdrawals began there. At this point federal regulators, close to panic themselves, promised to protect large depositors in large banks. But depositors no longer believed them after the losses at Penn Square, and the withdrawals continued. In the end, regulators had to essentially nationalize the Continental Illinois Bank before their promises became credible.

Before the next banking crisis strikes—and there is bound to be one in a world where the safety of depositors is not guaranteed—it is my hope that the current administration will recognize that while some regulations are obsolete, others are not. Obviously, those government regulations that seek to prevent competition among financial institutions—limits on interstate banking and the activities that financial institutions can undertake—should be abolished. It's simply not fair to regulate the more traditional segments of the banking community heavily while the newer financial institutions go scot-free.

However, those regulations that seek to require honesty and safety—through federal audits, minimum requirements on capital, and deposit insurance—should be extended. Since the Continental Illinois case proved that the system cannot work if only small depositors are insured, all depositors should be insured. Since the Ohio disaster proved that the system cannot work with fraudulent bookkeeping, the government should require federal audits whenever depositors' funds are at risk. Laws providing for honesty and safety are not unwarranted intrusions into free markets. Quite the opposite, they are precisely what make free markets work. □

BY MICHAEL BARKER

Crying Wolf over Capital-Gains Tax Reform

THE Treasury Department's "tax simplification" proposal has managed to offend just about every special-interest group around. Why? Because it would eliminate most of the expensive loopholes in the current tax system: tax breaks for the oil and gas industry, tax-free fringe benefits, tax credits for investment, and deductions for charitable contributions and for state and local taxes. Treasury Secretary James Baker III, concerned that the plan might offend too many powerful Republican constituencies, has promised to retract any of its provisions if shown "evidence" of hurtful effects. That was probably a mistake, for the line of would-be victims, armed with printouts from their favorite economic models, now stretches far down Pennsylvania Avenue.

Unfortunately, one of the biggest objects of complaint is also one of the best items in the plan. That's the proposal to tax capital gains as ordinary income, with a top marginal rate of 35 percent and the gain adjusted for inflation. Currently, the top effective tax rate on capital gains is 20 percent, and there is no adjustment for inflation. (Taxpayers can exclude 60 percent of realized capital gains from tax. The 20 percent represents the top marginal tax rate on ordinary income of 50 percent applied to the unprotected 40 percent of capital gains.)

George Gilder, the leading pamphleteer of supply-side economics, has written in The *Wall Street Journal* that the Treasury's proposal is tantamount to a "war on entrepreneurs." He claims that its enactment would attack "the very lifelines of venture capital and the new equity markets that have made the U.S. the Mecca of the world's most creative businessmen and women."

Gilder's cry has been taken up by Wall Street stockbrokers, corporate executives, and lobbyists for the venture-capital industry. Without a special low rate on capital gains, they say, risk-taking will be discouraged. Venture capital will be starved for funds. Entrepreneurship will flag, and fewer new companies will be established. Investors will shift their assets toward less productive and less risky investments—the "gimme shelter" effect. The stock market will be dragged down. A blight will move slowly across the face of the land.

MICHAEL BARKER is editor of "Politics & Markets," a monthly newsletter, and executive director of the Gallatin Institute, a nonprofit economic-policy research group based in Washington, D.C.

The problem with this argument is that there is nothing to it. There's no evidence that it is true, and considerable evidence that it is not.

The Bulldozer Effect

The problem with the current capital-gains tax is that it taxes *nominal* rather than *real* capital gains. For instance, if you invest $100,000 and after a year, your investment is worth $125,000, the nominal gain is $25,000. However, if inflation is 10 percent, the real gain is only $15,000, yet you would pay taxes on $25,000. As a result, when inflation is high, investors can easily be hit with taxes on non-existent real income. That is obviously unfair.

The tax system has provided favorable tax treatment for capital gains since the early 1920s, when the impact of postwar inflation on real asset values was immediately apparent. Then, and for the next 50-odd years, it was generally agreed that the purpose of this special treatment was to ensure that taxes and inflation didn't interact to produce a *disincentive* to investment. Indeed, people seemed quite able to grasp a fundamental fact about financial investment: greater risk is accompanied by the possibility of greater reward. Unless that reward is undone through discriminatory tax treatment, it is in itself sufficient compensation for the investor.

But compensating for the potential effects of inflation on asset values by excluding a portion of capital gains from taxable income has always been a very blunt instrument. It is like weeding a garden with a bulldozer. When inflation is high, as it was in the late 1970s, even the current 60 percent exclusion rate will not compensate investors for the erosion of asset values. On the other hand, when inflation is low as it is now, any investor with assets appreciating in excess of infla-

ILLUSTRATION: ELIZABETH SLOTE

tion will be grossly overcompensated—indeed, subsidized.

This is why virtually all serious students of tax policy feel that the capital-gains tax should be indexed to inflation. With indexing, taxpayers would be taxed only on real increases in the value of their assets—and not on purely inflationary increases.

George Gilder and Wall Street supply-siders say the current tax system provides a crucial incentive for entrepreneurship. They claim that the enormous growth of venture capital since 1978 is the direct result of the fabled "Steiger Amendment." Introduced by the late Congressman William Steiger (D-Wisc.), this cut the top marginal rate on capital gains from 49 percent to just 28 percent. It was followed, in 1981, by a further drop to 20 percent.

Gilder and his fellow supply-siders say that an increase in the capital-gains rate would "dry up" the sources of new money flowing into the venture capital industry. This is nonsense, pure and simple. To see why, we need only look at the tax status of those who invest in venture capital.

Some 40 percent of the money committed to venture capital in 1984—$1.26 billion—came from pension funds, foundations, and endowments. All are tax-exempt investors for whom the capital-gains tax is simply irrelevant. Another 18 percent came from foreign sources not subject to American taxation.

Of the remaining 42 percent, 28 percent came from insurance companies and other corporations (such as banks) that are able to manipulate the timing of their income to ensure a low rate of taxation. Only 15 percent of the money invested in venture capital came from individual investors subject to the capital-gains tax.

In short, most of the new money in the industry has come from institutions and individuals largely unaffected by the capital gains tax. It wasn't the big cut in tax rates that led to the explosion of venture capital at all. Other forces were at work. One of the most important was the liberalization of the investment guidelines of the Employee Retirement Income Security Act (ERISA) in 1978. In essence, this action by the Department of Labor allowed private pension managers to invest a relatively small fraction of their total pension-plan assets in more risky investments, including venture capital. State pension funds quickly followed suit. As a result, private and public pension funds are now

Continued on page 26

BY HERBERT LIN

The Software for Star Wars: An Achilles Heel?

June 2006: Several hundred Soviet intercontinental ballistic missiles (ICBMs) are launched at the United States. Their hot exhaust plumes make them visible to American satellites, enabling our laser battle stations to attack and destroy most of them. However, some of these missiles are designed to detonate their nuclear warheads if destroyed. These nuclear detonations generate intense thermal pulses that temporarily disable the infrared sensors searching for warhead carriers. These sensors take some time to recover, but they eventually find the carriers that survive and transmit their data to the next defensive layer. The computer program processing these data expects to receive them at a certain speed. But the initial disabling of the sensors means that the program must receive the information in a much shorter time than anticipated. The data cannot be processed as fast as they arrive, and therefore some are lost. As a result, several carriers go undetected, and their warheads penetrate to their targets untouched by the remaining defenses.

> *Developing reliable software for ballistic-missile defense is a monumental, if not impossible, task.*

FANCIFUL? Yes. Utterly impossible? Not at all. The debate over the Strategic Defense Initiative (SDI), popularly known as Star Wars, has focused largely on individual items of hardware in the proposed system: the effectiveness of particle beams, lasers, and electromagnetic rail-guns, as well as the number of satellites required. Very little of the debate has addressed the difficulties of integrating these components into an effective and functional system. One of the most important ingredients of the complete system will be the computer software used to coordinate the individual components and monitor both the threat and progress of battle. And this is where a potential Achilles heel of SDI can be found.

President Reagan has repeatedly articulated the goal of defending the entire nation against missile attack. This is an extraordinarily demanding aim, since it requires near-perfect effectiveness; even 1 city destroyed out of 300 attacked would be a disaster unprecedented in American history. The program required to run such a system must be highly reliable, and that is the primary difficulty in developing software for a comprehensive ballistic-missile defense (BMD).

Unprecedented Complexity

Managing a comprehensive defense against ballistic missiles presents problems of unprecedented complexity. As Robert Cooper, director of the Defense Advanced Research Projects Agency (DARPA), notes, "We have no way of understanding or dealing with the problems of battle management in a ballistic-missile attack

HERBERT LIN is a postdoctoral research fellow in the Arms Control and Defense Policy Group of the M.I.T. Center for International Studies. He received his doctorate in physics from M.I.T. in 1979.

ILLUSTRATION: BOB DAHM

ranging upward of many thousands of launches in a short period of time, i.e. tens of minutes."

The Defensive Technologies Study Team (DTST), assembled in 1983 to examine the technologies needed for ballistic-missile defense, took note of these problems in its report to the Department of Defense (DOD): "[The development of] software for a battle management system will be a task that far exceeds in complexity and difficulty any that has yet been accomplished in the production of civil or military software systems." The team estimated that a software system of 10 million written instructions would be necessary. By comparison, the word-processing software for a home computer might require 5,000 instructions. The MULTICS operating system for mainframe computers totals a few hundred thousand instructions.

Debugging Star Wars Software

Complicating this monumental task is the fact that the software for BMD battle management cannot be tested in a realistic environment. The simultaneous launch of 500 American ICBM-like boosters as part of an ostensible test might be interpreted by the Soviets as a hostile act. Running small-scale tests, in which a BMD system intercepts only one or two missiles, and using computerized simulators to mimic large-scale threats may bolster confidence in the system. But this confidence would rest on the assumption that this experience could be extrapolated to an actual battle.

Developing other complex military software has proven difficult. The AEGIS system is designed to defend naval task forces against air attack. Its computer software, which is a few hundred thousand statements long, must track hundreds of airborne objects in a 300-kilometer radius and intercept targets that come within range of its defensive missiles. In its first operational test, the system failed to shoot down 6 out of 16 targets. The reason? Improperly written software.

Large software systems are difficult to plan and debug. Planning such a large software system is difficult because the details of a battle environment are impossible to anticipate. Therefore, assumptions made about the expected environment may not correspond to the actual environment. For example, the software may be designed to interpret a "hot flare" as a missile to be attacked, without regard to the geographic origin of the flare. If "hot flares" are detected over Cape Canaveral during times of tension, this could cause serious problems for space shuttle crews.

Of course, the program could be modified to make sure the computer cross-checks geographic origin before issuing attack commands. But someone would have to think of this modification in advance, and it is hard to think of *all* the modifications that might be necessary. Moreover, a change in one part of a large software system may have unanticipated consequences in another part.

One Mistake Too Many

Thus, software can assume a probabilistic character: the software may work most of the time, but on some occasions it will not. Worse still, it may be impossible to identify precisely the conditions under which it will not work. And because in the case of BMD the software must carry out its operation within minutes, there is no time for human intervention in the event of error or malfunction.

Are there alternatives to conventional software development? Some defense planners think so. Major Simon Worden of the SDI Office has said that "a human programmer can't do this. We're going to be developing new artificial intelligence [AI] systems to write the software. Of course, you have to debug any program. That would have to be AI too."

This optimism is not justified. No matter how sophisticated the software technology, human beings must specify what the system should do. Automatic programming systems—programs "smart" enough to write other programs—do not automate the design process. Rather, they make easier the process of implementing design specifications into actual code. An early example of automatic programming is a compiler that translates a high-level programming language such as FORTRAN into machine language that a computer can execute.

Automatic programming provides no assurance that the design specifications do, in fact, specify what the designers intend them to specify. In general, computers do what people tell them to do, not what people mean them to do. The significance of this limitation becomes clear when one notes that about two-thirds of all errors

Continued on page 18

Continued from page 17

in computer software are made in the specification and design phases.

Not Everyone Is an Einstein

It is fashionable for proponents of the SDI to dismiss claims of impossibility by citing the lessons of history. They point to American optimism and our "can-do" spirit—to the times when nay-sayers were proven wrong. But the mere fact that someone has stated that something is impossible does *not* mean that it is in fact possible. For every Einstein dismissed by colleagues and later vindicated by history, there are 10 others who were dismissed by colleagues and never vindicated by history.

Indeed, in 1966 Secretary of the Army Stanley Resor said that "the technical feasibility of the NIKE-X [anti-ballistic missile system] and the high probability that the design objectives will be achieved are generally accepted. All major engineering problems have been solved, and only minor design fixes are foreseen." What does history say about NIKE-X? In 1969, Congress voted to proceed with the deployment of an ABM system derived from NIKE-X. In 1976, Congress voted to shut down this very same ABM system because of doubts about its technical effectiveness.

Finally, software poses a set of questions different from those posed by hardware. Hardware is tangible; one can look at it, feel it, drop it. Software is intangible: one cannot feel it or look at it, let alone drop it. Software is more similar to a thought process than to hardware, and therein lies a judgment call. One may argue that since no fundamental limits constrain human thought, software (in contrast to hardware) can solve problems of unlimited complexity. However, one may also argue that software is subject to the restraints imposed by the limited capability of the human brain to understand and program for complex systems.

No one can know with certainty how the BMD software would work during a large-scale attack. How much confidence should the American public have in a BMD system so complex that no one person can understand it? That cannot be certified as error-free? That is operationally untestable? The lessons learned from the performance of other large software systems suggest that the answer might be "very little" confidence indeed. □

Continued from page 4

limited to males. Certainly that is one of the most serious and blatant sexual discriminations in the history of this country.

If the G.I. Bill casts such a long shadow upon women today, it is only fair to also recognize the much darker shadow conscription into war cast upon men during World War II.

Michael D. Zuteck
Kemah, Tex.

Mr. Zuteck graduated from M.I.T. in 1967. He did not serve in the war nor was he ever eligible for the G.I. Bill.

An unabashed fan note! Lilli Hornig's article is splendid. I have already used the opening anecdote about how "women prefer knives" at least three times. I found the suicide rate among female chemists over those 25 years a shattering figure. What I like most is the clear marshalling of empirical information that forces one to confront the factor of unconscious discrimination.

John William Ward
New York, N.Y.

Mr. Ward is president of the American Council of Learned Societies.

The author responds:

The statement to which Professor Buchwald objects, evidently with justification, represents my best recollection of a story told to me during several days' stay at Carleton as the Elizabeth Nason Distinguished Woman Visitor five years ago. Clearly I should have checked the information, and I hope the department—and your readers—will accept my apologies.

Mr. Zuteck's comments regarding the "social-justice" aspect of veterans' educational benefits present a difficult problem. No evidence suggests that this legislation was intended primarily to compensate individuals for military service. In fact, the record supports the reading I have given—that the benefits were intended to ameliorate the dislocations that would inevitably result from the sudden dumping of several million men into an uncertain peacetime economy. The ready acceptance of such an expensive program by the public, on the other hand, surely rested on the "social-justice" argument.

The higher-education community vigorously opposed such benefits, arguing that most of these men would be unsuited for college because they had inappropriate educational or social backgrounds, or because they were too old, married, or fathers. A few universities were so concerned that they created special programs and degrees or "veterans' colleges" to keep their "real" students and degrees pure. The universities quickly abandoned these programs once the veterans were on campus and demonstrated their qualities. Those of us who taught the returning veterans were unanimous in applauding their ability and dedication.

Any potential impact of the bill on women's education was not, as far as I can tell, considered at any level. There are two likely reasons for such an omission. First, women's higher education and their possible employment in the postwar period were not seen as matters of serious concern. And second, the enormous success of the bill, its perpetuation through later wars, and its expansion to peacetime draftees were simply not foreseen. As I stated originally, the damage to women's prospects in higher education and subsequent careers was inadvertent but nonetheless real.

The point is an important one in the history of women's participation in higher education generally, and in the sciences particularly, because it shifts the focus away from women's own behavior and toward a more realistic examination of barriers to their full participation. Such a shift is essential if women are eventually to attain equal access.

Giving the Public a Say in Environmental Risk

The Environmental Protection Agency's "new strategy of involving the public in managing environmental and health hazards" is a refreshing change from past practice. (*See "Environmental Risk: Power to the People" by Barnett Kalikow, October, page 54.*) An educated public can better distinguish actual from perceived risks, and work to change objectionable aspects of generally acceptable programs.

Public support is necessary for a democracy to function. Measures that involve the public in making economic decisions—for which they will have to pay the price as well as gain the benefits—are a step in the right direction.

Bruce Brager
Arlington, Va.

Physics of Time, Navigation Video, and Cancer Crusade

The Physics of Time and Order

Order Out of Chaos
by Ilya Prigogine and Isabelle Stengers
Bantam Books, $8.95

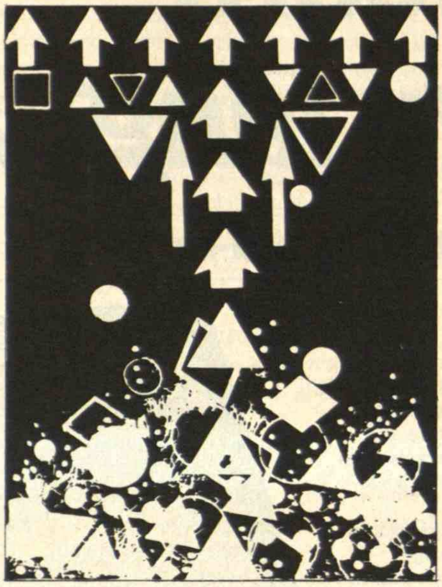
Reviewed by David Layzer

Many processes of everyday life are irreversible. Ice cubes placed in hot tea cool it as they melt, but we will wait in vain for the ice to re-form. Gasoline once burned in the engine of a car cannot be reconstituted from the exhaust gas. Electricity can be used to heat water, but only a small fraction of the heat generated can be turned back into electricity. All these processes convert order in one form or another into disorder. According to the second law of thermodynamics, they cannot be turned back. They always proceed in the forward direction of time. In fact, they define that direction. The British astrophysicist Arthur Stanley Eddington once said that they equip time with an arrow.

However, an observer who could see individual molecules and their motions would form a different picture of the world. Such an observer wouldn't perceive a distinction between order and disorder, and so wouldn't be able to formulate the second law of thermodynamics. The direction of the future would be indistinguishable from that of the past. For example, if the velocities of the molecules in a gas were suddenly reversed, they would simply retrace the steps they had taken.

How can we reconcile the manifest irreversibility of the macroscopic processes of everyday life with the apparent reversibility of the underlying microscopic processes? Physicists' classical answer is that macroscopic processes *are* reversible: ice cubes *can* form spontaneously in water, but the initial conditions—the precise locations and velocities of individual water molecules—that would give rise to such an event are exceedingly rare. But why are they rare? Why shouldn't the universe have been constructed in such a way that ice cubes routinely form in glasses of water?

In *Order Out of Chaos*, Ilya Prigogine, a physical chemist and Nobel laureate, and Isabelle Stengers, a historian and philosopher of science, seek to answer this question. And they ask a second, related question: If order always tends to decay, as the second law says it must, why is there so much of it in the world? Why has the universe failed to achieve that state of perfect chaos toward which, according to the second law, it continually strives?



The Origin of Irreversibility

Prigogine and Stengers argue that the tendency of order to dissolve into chaos is rooted in a *dynamical instability* of certain complex systems. An unstable system (such as a gas) evolves in a radically different way if the initial conditions are altered only slightly. This concept can be illustrated by the following imaginary experiment:

Picture a box divided in two by a partition. Initially the lefthand compartment is filled with air and the righthand compartment is a vacuum. If you make a tiny hole in the partition, soon there are nearly equal numbers of molecules in the two compartments. Imagine now that the velocities of all the molecules could be suddenly reversed. Because the laws that govern collisions of molecules do not discriminate between the two directions of time, every molecule would simply retrace its path (provided the box were shielded from all outside influences). The molecules on the right side of the partition would make their way back through the pinhole, leaving the righthand compartment empty once more.

If, however, the velocities were not reversed precisely but only approximately, the outcome would be qualitatively different. Nearly all the molecules that would have gone back through the pinhole if their velocities had been exactly reversed now would miss the pinhole, and the numbers of molecules in the two compartments would remain nearly equal. The system is dynamically unstable because a minute change in the initial conditions causes a large change in the subsequent history of the gas.

Prigogine and Stengers argue that the molecular configurations that would cause ice cubes to form spontaneously in water are not only rare but also dynamically unstable. This implies that such states cannot be prepared in the laboratory: to do so a physicist would need instruments capable of unattainable precision.

So far the argument is sound—and not particularly novel. Now it takes a surprising turn. The authors assert that what a physicist cannot obtain in the laboratory, nature cannot obtain either. If dynamic instability makes it impossible for physicists to create initial conditions that will cause ice cubes to form in water, such conditions cannot exist. Why? Because, claim Prigogine and Stengers, modern physics has taught us that the traditional distinction beween the observer and the observed—between objective physical reality and the physicist who observes and manipulates it—can no longer be maintained. Physical laws, they say, must refer to the outcomes of possible measurements rather than to an ideal, detached reality.

The Origin of Order

How does order come into the world? For Prigogine and Stengers the following example is paradigmatic:

Imagine a shallow pan of water heated from below by a gas flame. As long as the temperature difference between the bottom of the pan and the surface of the water is small, the water remains still. Now suppose that the gas flame is slowly turned up, causing the temperature difference to increase. When it reaches a certain critical value, the water begins to move. A regular geometric pattern of hexagonal convection cells develops. In each cell, water rises in a central column and runs down at the edges. Prigogine and Stengers call this pattern of convection cells a "dissipative structure." Why "dissipative"? Friction is

normally an agent of entropy, dissipating order, but here that very force—internal friction in the water—plays an essential part in the emergence of the ordered structure. Without internal friction, the smallest temperature difference would cause chaotic motions rather than orderly cellular convection.

Dissipative structures are important in several branches of macroscopic physics, including meteorology and physical chemistry. Tornadoes are related to such structures, and so are certain experiments in which a mixture of reacting chemicals produces colored patterns that undergo rhythmic variations.

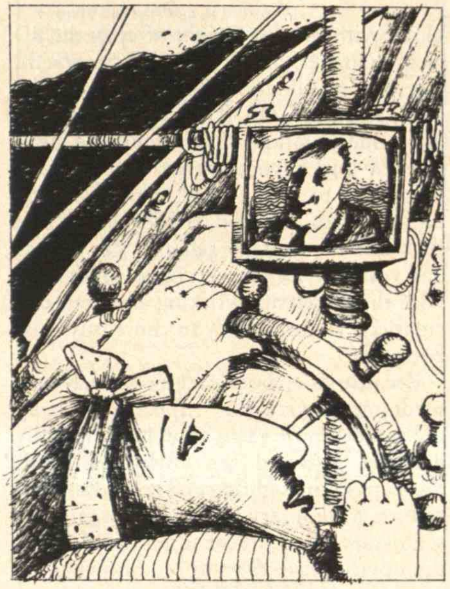
Prigogine and Stengers maintain that dissipative structures are important in creating order in much wider contexts. In particular, they suggest that dissipative structures forming in the primordial prebiotic soup may have been instrumental in bridging the gap between nonliving and living matter.

A Conceptual Revolution

The authors of *Order Out of Chaos* claim to describe a "conceptual revolution" that is changing the way scientists look at time, change, order, and irreversibility. They are to be congratulated for their impressive attempt to bring these scientific and philosophical issues to a wide audience. And their ideas do indeed have revolutionary implications. For example, Prigogine's theory of thermodynamic irreversibility would require far-reaching changes in the laws that govern elementary particles and their interactions. But are the proposed solutions valid?

Many physicists would agree with the authors that the irreversible behavior of a gas results in part from the fact that its history is sensitive to small changes in the initial positions and velocities of its molecules. They would also agree that this instability makes it impossible in practice to predict the long-term history of an isolated gas. However, I am not convinced by the authors' claim that "in practice" implies "in principle." Their arguments are philosophical rather than scientific. In my opinion (though others would disagree), neither the theory of relativity nor quantum mechanics challenges the thesis that physical laws refer to an objective reality, independent of physicists and their measurements.

I find Prigogine and Stengers' solution



to the problem of order equally unconvincing. They repeatedly imply that dissipative structures hold the key to an understanding of all kinds of orderly structures, from nucleic acids to galaxy clusters. Most students of the origin of life believe that the first living systems were self-replicating molecules—precursors, perhaps, of modern RNA. The formation of a self-replicating molecule in a soup that contains the molecule's building blocks along with a suitable source of energy to fuel replication does indeed trigger an instability. But it is very different from the kinds of instability that give rise to dissipative structures such as convective cells and tornadoes.

Still different processes give rise to astronomical order—the prevalence of hydrogen (a chemically disorderly universe would consist mainly of iron) and the hierarchy of astronomical systems such as planets and their moons, solar systems, and galaxies. Both biological order and astronomical processes are accompanied by dissipation—that is, the growth of entropy—but in neither, in my opinion, does dissipation play an important role. A better explanation for the emergence of order must still be sought. □

DAVID LAYZER, Donald H. Menzel Professor of Astrophysics at Harvard University, is the author of Constructing the Universe *in the Scientific American Illustrated Library (1984) and is working on a book on order.*

Home Video Goes Instructional

Celestial Navigation Simplified
With William F. Buckley, Jr.
Avant Communications, $69.95

Reviewed by Joan Baum

In this instructional "video book"—the industry term for a videocassette of any subject that is not a movie—William F. Buckley, Jr., promises that we can use celestial navigation to sail from anywhere in the world and arrive at our destination. But at the end of the film, he urges us to write him if we're lost at sea . . . care of the Democratic National Committee.

The wit, the charm, the erudition are familiar, but Buckley, the noted political commentator and author, has positioned himself on a different kind of firing line in *Celestial Navigation Simplified*. This one is a "line of position" (LOP) which, when intersected by other plotted lines, will yield information about where we are at sea. Actually, about where we are not, for as our genial host declares, celestial navigation functions by giving us the "exact measure of our misjudgment." Plotting the points for celestial navigation also involves reconstructing the Ptolemaic universe of centered earth and revolving sun, as it is a system for mapping space-time onto two dimensions.

Anyone who has read or seen the video version of *Airborne*, Buckley's 1976 best-selling account of his first trans-Atlantic sail, will understand the need for celestial navigation: Buckley's electronic navigational gear was inoperative most of the time. He responded with this film, to be played on a videocassette recorder (VCR), that purports to teach in 40 minutes a complex calculation that Buckley says can be done in 4.

Video books are not simply electronic textbooks. For a subject like celestial navigation, which turns on spherical trigonometry, the combination of computer graphics and photography enhances learning, as does the possibility of repeated viewing. Outdoor shots alternate with closeups of reference tables; music is heard occasionally, a rolling sea glimpsed. The presence of an articulate narrator is also important in giving video instruction an edge over print. Buckley, sky-blue sweater setting off his pale blue eyes, talks to us

On a clear day you may see forever; on a cloudy day you can easily miss Bermuda.

from a large leather armchair with his mind at play, his polysyllabic articulations cascading over mid-sentence pauses. Yet he is properly understated for the occasion and the script is lean.

Aiming for Bermuda

Celestial Navigation Simplified will not replace a standard offshore course but it can complement one, especially for the busy professional. When replayed several times, the overview, nine-part exposition, concluding summary, and accompanying printed worksheet should provide both beginning and experienced sailors with enough to talk about and do during those long lulls that are among the most dangerous hazards of ocean sailing.

Nonetheless, the subject is difficult and the instruction will be heavy going for the neophyte. Buckley teaches HO 249, the "easiest" of the celestial navigation systems, yet the array of acronynms involved can baffle even an experienced sailor. There is the GMT (Greenwich Mean Time) correction to be made on the WT (watch time), the IE (index error) to note, along with the dip (height of eye), the SD (semidiameter), the HO (height observed), the dec. (declination, or latitude of the sun), and the GHA (Greenwich hour angle). Interpolation charts must be deciphered and several other calculations made—all to get an LOP, which isn't yet our point of location. Heady stuff, and then not even totally reliable. On a clear day you may see forever; on a cloudy day, with the Loran not working and your calculations slightly off, you can easily miss Bermuda.

Because video books are a relatively new medium, viewers may expect to pick up the subject more easily than is realistically possible. Although the worksheet distills the steps in the sighting and recording procedure, a summary of the nine points and a glossary of technical terms would help the novice grasp the subject. Showing the overview statements on screen would also reinforce the message without compromising the value of the video medium. Sophisticated viewers may want to rig up an index-counter to locate individual sections of the film.

Video books are a potentially powerful product with enormous possibilities for instruction. Interestingly, Avant Communications, the publisher, reports that many of those interested in celestial navigation are women, who see expertise in the technique as a way to move out of the galley. Avant is also planning to release a cassette on health care and another on New York's Cooper-Hewitt Museum. Already out, in the nature of documentaries, are *The Last Sailors* narrated by Orson Wells and a video version of photographer Robert Vavra's *Such Is the Real Nature of Horses*. Indeed, sales of nonmovie video now comprise 15 percent of the billion-dollar, 18-million-unit VCR industry.

Video books do especially well at holiday time. Last December Abercrombie and Fitch showed *Celestial Navigation Simplified* in its new store at New York's South Street Seaport. How fine, after dinner, to see it on the cabin coffee table at the serving of the chartreuse. □

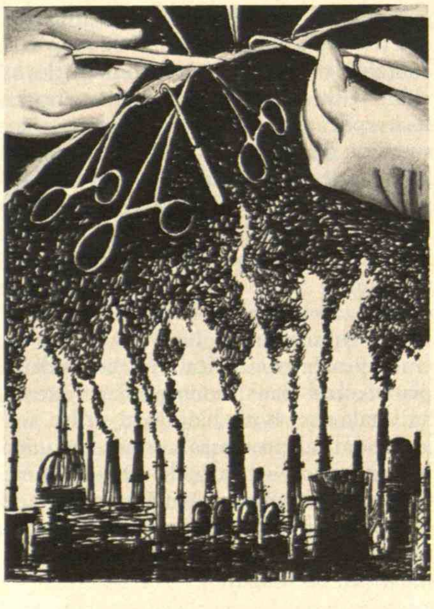
JOAN BAUM, an amateur but avid sailor, teaches English at York College of the City University of New York.

Cancer Crusade

The Apocalyptics: Cancer and the Big Lie
by Edith Efron
Simon and Schuster, $19.95

Reviewed by Gerald Wogan

In *The Apocalyptics,* media critic and best-selling author Edith Efron tells of her discovery of "a cultural crime which should not be possible in a free society: a complex corruption of science and a prolonged deception of the public" regarding the causes of cancer. Efron maintains that a band of irrational antitechnology, anticapitalist "environmentalists," members of the counterculture of the 1960s, conspired to exaggerate the role of industrially produced chemicals in human cancer. She believes that these scientists manipulated a gullible press into promulgating their mythical theories, and identifies five principal villains: Rachel Carson, Paul Ehrlich, Barry Commoner, René Dubos, and George Wald, all of whom wrote popular



books during the 1960s and 1970s.

Efron maintains that these cancer apocalyptics put forward three fundamental axioms. The first—the "Garden of Eden" theory—held that most carcinogens are synthetic chemicals. The second axiom held that 90 percent of cancer is caused by environmental factors. The third idea, a derivative of the first two, predicted that a cancer epidemic was imminent owing to people's increasing exposure to industrial chemicals since the end of World War II. Although Efron is right in saying that these were among the important concerns of environmentalists and many other scientists during those two decades, the axioms were considered hypotheses to be tested rather than proven results.

In fact, Congress and the Nixon administration initiated the National Cancer Program in the early 1970s in response not to apocalyptic voices but to the convictions of a broad spectrum of scientists, physicians, and laypeople that the technical groundwork had been laid for a frontal attack on all aspects of the cancer problem. Relatively little was then known about the risks from carcinogens in the human environment. In the ensuing years, billions of dollars from federal agencies and private organizations have been used to improve cancer diagnosis, treatment, control, and prevention. This massive en-

deavor has yielded a vastly improved understanding of the mechanisms by which chemicals and viruses cause cancer.

We now know that many chemicals of both human and natural origin induce cancers in experimental animals, and that people are exposed to a multitude of these substances in the course of daily living. Whether these chemicals actually cause cancer—beyond the well-established association between cigarette smoking and lung cancer, and a small number of cancers induced by certain drugs and workplace chemicals—is unknown. Research shows that diet and lifestyle also interact with these factors to influence cancer risk. Since preventing exposure to naturally occurring carcinogens is difficult, regulators have focused on limiting people's exposure to synthetic chemicals.

A Simplistic View

The author marshals massive evidence from the scientific literature to discount the results of research on the carcinogenic effects of chemicals, yet her own views are highly distorted and simplistic. For example, she concludes that because the huge volume of animal experiments is so full of contradictory evidence, they are totally invalid for predicting cancer in humans. However, if she had delved more deeply into these experiments, she would have found impressive evidence that chemical carcinogens mutate human cells and tissues much the way they change animal cells and tissues. Thus, people exposed to animal carcinogens, whether synthetic or naturally occurring, are at some level of risk. Furthermore, scientists make use of a broad spectrum of tests to corroborate animal experiments before deciding which chemicals should be regulated.

In attacking the uncertainties of the regulatory process and its scientific underpinnings, the author creates the false impression that environmental factors play no role in causing cancer. She may therefore engender in readers a cynical fatalism concerning opportunities to reduce their own risk of developing cancer. ☐

GERALD WOGAN is Underwood-Prescott Professor and chairman of the Department of Applied Biological Sciences at M.I.T.

Rethinking the Legacy of Los Alamos

BY DIANA BEN-AARON

> *Scientists who helped build the atomic bomb call for an end to the arms race.*

On the fortieth anniversary of the first nuclear explosion, 6 of the 11 Manhattan Project scientists now at M.I.T. urged Americans to put the genie of the nuclear arms race back into the bottle. The occasion was the 1985 Karl Taylor Compton lecture at M.I.T., and it provided an historic opportunity to bring together many of the alumni of the Los Alamos A-bomb project.

"Those of us who were involved in what you might call the original sin have been working ever since to contain the effects of our invention," M.I.T. physics Professor Bernard T. Feld told the 400 students, staff, and faculty members gathered at the April 17 event.

"We went out and made public speeches about the bomb" after the war, said Institute Professor of Physics Victor Weisskopf. "We wrote many articles and we tried to create committees such as the Emergency Committee of Atomic Scientists headed by Albert Einstein."

Their intent was to contain nuclear weapons through international agreement. "We hoped to end the age-old custom of organized mutual mass murder," Weisskopf said. But the world was not ready to hear their voices, and the need for action is more urgent now than ever.

"At this moment in history, we are on a collision course. Time is running out," Weisskopf warned. He urged the MIT community—particularly the young people because "they are the ones who will make things change"—to work for the end of the nuclear arms race through politics, mass demonstrations, and, if necessary, civil disobedience.

It was, in fact, young people, working through the M.I.T. Student Disarmament Study Group, who came up with the idea for this year's Compton Lecture. They enlisted the aid of the Office of the Provost, which sponsored and organized the all-day event. The program began with an afternoon showing of *The Day After Trinity,* a documentary on the Manhattan Project based on interviews with Los Alamos scientists.

After the film, six veterans of Los Alamos—Feld, Weisskopf, physics Professors Martin Deutsch and Philip Morrison, and metallurgy Professor Cyril S. Smith, and electrical engineering Professor Jerrold Zacharias—participated in a panel discussion. Weisskopf, Morrison, and Kayatyani Bajpai, the Indian ambassador to the United States, jointly gave the formal Compton Lecture in the evening. Immediately afterward, members of student and faculty disarmament study groups left for Washington to take part in the nationwide University Lobby Day to stop the arms race.

"The Work of the Devil"

Some of the lecture's participants began their remarks by recalling the first explosion of an atomic bomb 40 years ago in a New Mexico desert. Weisskopf said he would always remember it as "the day the sun rose twice.

"We were told to lie down on our stomachs with our faces away from the blast, but of course we could not do that because we would not be able to see anything. So after the generals had assumed that position, Phil and I put on our dark glasses—we had made them calculating that [the explosion] would have the light of 20 midday suns—and turned around.

"The only thing our calculations had not prepared us for was the heat on our faces in the cold New Mexico pre-dawn," Morrison recalled. "It has been suggested that there should periodically be held a ceremonial above-ground test so the world's statesmen can also feel the heat on their faces. That suggestion is not without its persuasiveness."

The Los Alamos veterans seem to feel that once fission was discovered, there was no turning back. "When fission was described in 1938, by Lise Meitner and Niels Bohr, every halfway respectable department of physics—across the world from Japan to the USSR—was able to duplicate within a couple of days the fission pulses," Weisskopf said. "If we hadn't constructed the atomic bomb, others would have sooner or later."

Deutsch offered another perspective: building the A-bomb, which he described as the "work of the devil," was "necessary for growing up. Mankind has passed its adolescence. There is no way to go back to childhood, to Paradise."

For those scientists who were directly involved, that turning point brought with it an enormous "feeling not of guilt, but of responsibility," said Smith. "We want people to know what happened and what it meant."

Some of the Los Alamos veterans have focused on entirely different areas of research in the ensuing 40 years. "When the war was over, I wanted nothing to do with weapons," Deutsch said. Instead, he concentrated on the applications of high-energy particle physics to medical and biological problems. Some—like Einstein, Weisskopf, and J. Robert Oppenheimer—began voicing concern over the further development of nuclear weapons. And some continued to work on bigger and better bombs.

"We [the United States] continued our work after the Hitler defeat because of the momentum of the military machine," Weisskopf noted. "By then it was—in Oppenheimer's phrase—a technically sweet project."

That momentum is still one of the reasons why no real progress has been made toward nuclear containment over the last 40 years, Weisskopf said. Fear is another pervasive reason, he said—fear of a first strike, fear of being weaker than the Soviet Union, fear that the Soviet Union will move aggressively against other countries unless we stay strong.

Weisskopf believes the leaders of both countries must somehow change their attitude of fear and "paranoiac mistrust" to one of mutual understanding. Americans, he said, must begin by recognizing that "you can't change a despicable system by force. You need to change the system in the Soviet Union by thawing—by letting them come over here and see how we live."

Another obstacle to nuclear disarmament is nationalism. "When Colonel William Lampton was engaged by the East India Co. to do a survey of India, his most

M.I.T. scientists gathered recently to mark the 40th anniversary of the first explosion of the atomic bomb. Here Professor Philip Morrison talks with Kayatyani Bajpai, India's ambassador to the U.S.

important instrument—the theodolite—was sent by sea and captured by a French ship. Three or four years later—no great delay in 1807—it was returned by the French Academy with a note saying, 'Please use it to generate your maps,'" Morrison said. "At that time, science was thought of as above national conflicts."

Today, science is almost always subjugated to nationalistic ends, Morrison maintained: "Now, of course, the figure of the earth is a top military secret. If you know where there are concentrations of mass and changes in the geoid that haven't yet been detected by satellite perturbations, you'd better not tell anybody, because it's very important for aiming and detecting missiles."

Another by-product of this obsession with national strength is a shortage of talented scientists to solve other important problems. "The increasing amount of carbon dioxide in the atmosphere and acid rain—now these are things that need scientists, scientific collaboration, and scientific investigation," Weisskopf pointed out. "But where are all our scientists? They are in defense."

In his speech, the Indian Ambassador acknowledged that the existence of the bomb has prevented war between the great powers for the last 40 years. But he warned that this situation will not last much longer. "The larger nations have kept the balance of power while they sowed the seeds for war and denied the small nations their rights," Bajpai said. "So far the scales have maintained equilibrium. But if we keep piling them up, the scales will break."

The danger of nuclear weapons, Deutsch said, comes not from their possession but from the inability to control "sudden attacks of insanity." As Morrison noted, "A mutual suicide pact is not a stable situation." Zacharias concurred, saying, "It doesn't matter who pulls the trigger, or which chip in which computer sets off the accident, the point is that we share a common peril."

A number of scientists criticized the Strategic Defense Initative (SDI), better known as Stars Wars. Morrison noted that the technical feasibility of SDI is not the real issue. It is that the United States can not possibly construct a permanent defense against nuclear attack. "Once the SDI weapons are built, they will be useless against the system the Russians will inevitably build to counter them. In the meantime, we will have started another arms race with extraordinary new orders of magnitude."

Instead of building more weapons, Morrison suggested that the United States make the first move in slowing down the nuclear arms race. "Representative Pat Schroeder [D-Colo.] has just proposed a resolution that goes like this: 'Let it be the sense of Congress that before August 6, 1985, the President shall declare a three-month freeze on nuclear testing, provided only that the Russians do the same.' Then we can continue the freeze indefinitely, reviewing it every 3 to 6 months and instituting other measures.

"Now that has the flavor of an initiative that does not compromise the peace. That has the flavor of what will work." □

DIANA BEN-AARON, former editor-in-chief of The Tech, *graduated from M.I.T. this June with a degree in humanities and materials science. She wrote her senior thesis on scientists' attitudes toward social responsibility.*

The tax rate on capital gains is just not something entrepreneurs worry about.

Continued from page 15
the single largest source of new venture capital, and their share of total venture investment continues to grow.

Inflation has also been an important factor. In the mid to late 1970s, major institutional investors, such as life insurers, found their investment portfolios savaged by sky-rocketing inflation and the collapse of the bond market. Along with real estate, venture capital seemed to offer a way to "inflation-proof" their portfolios. At the same time, a resurgent stock market reopened the window for new public offerings, making it easier for venture capitalists to take their companies public. A mergers and acquisitions boom made it easier still for venture-backed companies to be merged into large firms.

Impressive Profits Before and After Tax

In thinking about the impact of the capital-gains tax on venture capital and "entrepreneurship," it's important to distinguish between three sets of actors: the entrepreneur; the venture capitalist, who is usually the general partner in a limited partnership; and the investor, whose money the venture capitalist is investing. (Investors are almost always limited partners and most, as already mentioned, are simply unaffected by the capital gains tax.)

The entrepreneur. Most entrepreneurs have nothing to do with the capital gains tax. They start companies without the assistance of venture capitalists, and even when they are successful, most never reach the point at which they are able—or, for that matter, willing—to sell all or a portion of their companies. So they do not face capital gains.

While it is difficult to generalize about successful high-tech entrepreneurs, one thing is certain: virtually all expect to be terribly successful and terribly rich. The marginal rate of tax on future capital gains is just not something they worry about. (When Steve Jobs formed Apple Computer, the marginal rate on capital gains—then at a high of 49 percent—was plainly the furthest thing from his mind.)

The American economy has become entrepreneurial on a massive scale. More than half a million firms are started every year. But less than half of 1 percent of these firms are in the high-growth, high-profit fields that interest venture capitalists. The rest are restaurants, small foundries, paper-recycling services, and other small businesses.

So it is not true that the vast profits and wealth of a few very successful entrepreneurs are what drive most entrepreneurs elsewhere in the economy.

The venture capitalist and the investor. From 1970 to 1974, $367 million in new capital was committed to venture investments. The average pretax rate of return on those investments was 23.4 percent. This means that such investments should eventually generate capital gains of about $2.6 billion over the lifetime of venture-capital partnerships. A study by the Gallatin Institute estimates that the general partners' share of that total capital gain should be some $527 million. That makes their *average* annual return on investment a whopping 64.5 percent. Limited partners, by contrast, would get an average annual return on investment of 21.1 percent—much smaller, but still impressive.

From 1975 to 1980, when the average pre-tax rate of return on venture investment leaped up to 32.5 percent, new capital investments of nearly $1.7 billion should yield capital gains of about $26.6 billion. The share going to venture capitalists comes to a tidy $5.3 billion, for an annual rate of return of 77.7 percent. Since 1980, the pretax return on venture investment has risen still higher, to around 40 percent. These are impressive returns, particularly for the venture capitalist, who is largely investing what's known in the trade as Other People's Money.

Do taxes wipe out these extraordinary profits? Hardly.

When the general partner's pretax annual rate of return on investment is 77.7 percent, a 20 percent capital-gains tax produces after-tax annual returns of 73.8 percent. A 28 percent tax brings after-tax returns of 72 percent. Neither tax rate significantly affects the venture capitalist's rate of return. Even a 49 percent tax leaves venture capitalists with an after-tax annual return on investment of 66.2 percent.

When returns are this high, small differences in the rate of taxation are simply irrelevant.

Why, then, has there been such a hue and cry over Treasury's plan to reform the capital gains tax? The answer is simple: the current tax system is a great boon for wealthy taxpayers. It allows most to be taxed at much lower rates than ordinary taxpayers despite much greater incomes.

To paraphrase Scott Fitzgerald, the rich are different from you and me—not only because they have more money, but also because they get their money through capital gains. As a result, wealthy taxpayers can increase their wealth more rapidly than ordinary taxpayers can. Why? Because capital gains are taxed only when they are realized, and then at a special low rate. But unrealized capital gains still represent an increase in net wealth that can be used to assemble even greater wealth.

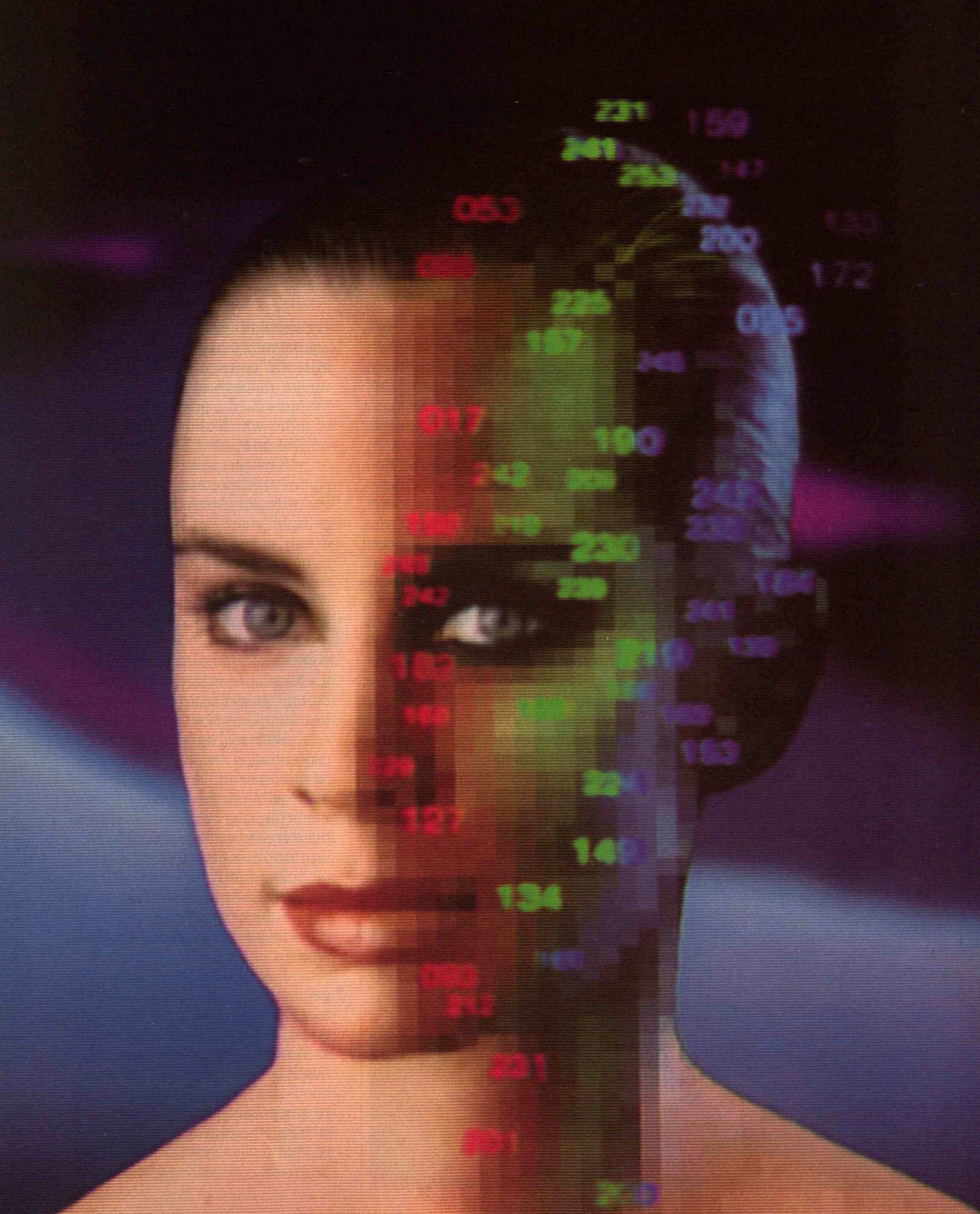
Waving the Flag of Entrepreneurship

Along with the stepup in asset values that occurs when assets are bequeathed to one's heirs, and the trivial estate taxes paid by anyone with a competent accountant, the capital-gains tax is a very good deal for the rich. Since they don't want to pay added taxes any more than anyone else, they are doing all that they can to scuttle Treasury's reform plan. It is a clever strategy. Wrapping themselves in the flag of entrepreneurship, they argue that wealthy taxpayers will be "forced" to put an increasing share of their assets in less risky—and less productive—investments.

At the same time, Washington's "capital-formation lobby"—the people who brought us the enormous tax breaks for business in 1981—have also joined the fray. They raise the specter of international competition, noting that neither Japan nor West Germany taxes the capital gains resulting from most portfolio stock transactions. The proper response is "so what?" Has the absence of a capital gains tax stimulated the emergence of a venture-capital industry in either country? Has it created a vibrant stock market? Has it made young people of either country entrepreneurial? No way.

In a better world, where people understood that businesses don't pay taxes and that tax-writing committees are dominated by special-interest PACs, we would tax capital gains after indexing them for inflation and adjusting them to reflect the effect of retained earnings on stock values. While this isn't going to happen in the near future, the Treasury's proposal is a modest step in the right direction. It would make the taxation of capital gains more equitable and efficient. It would do nothing to harm the venture-capital industry, and would be an irrelevant consideration for the nation's entrepreneurs. To say the least, it deserves a better reaction than it's getting.

The Reflective Vision



The Reflective Vision

A highly advanced design tool developed at the General Motors Research Laboratories uses computers to generate visual images from mathematical data with such accuracy that, soon, in-depth aesthetic evaluations of new concepts may be made prior to creating a costly physical model.

Interactive Display

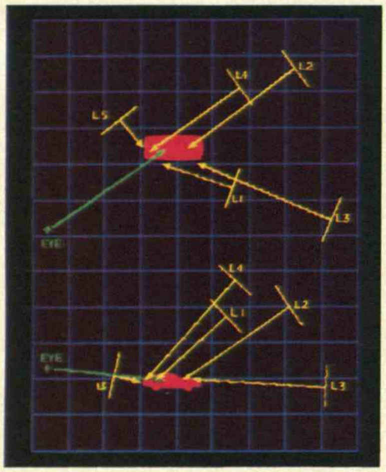
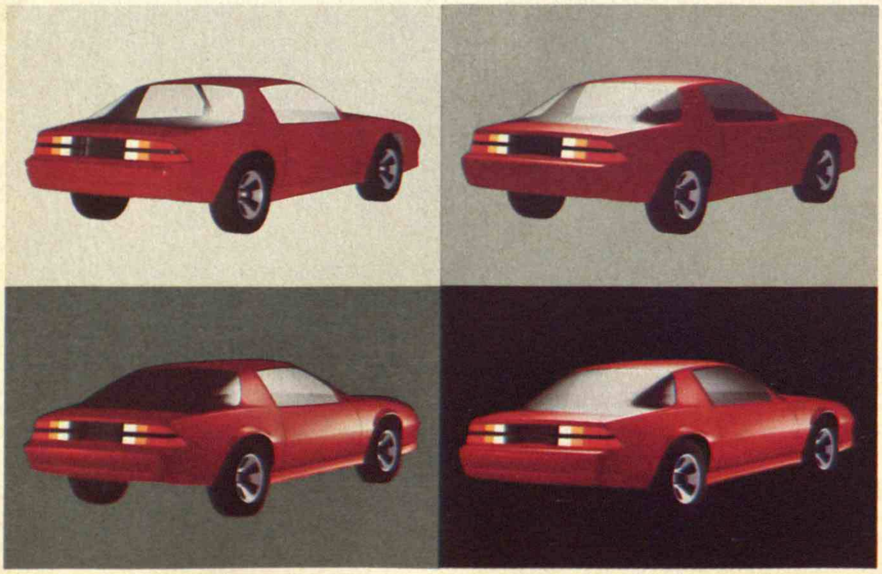


Figure 1: Computer display of plan view (upper) and side elevation (lower), indicating automobile location (red), lighting selections (L1-L5), and viewing position (EYE).

Figure 2: Four Autocolor images, showing the same view of an automobile as background and lighting change.



WITH AUTOCOLOR, users can synthesize three-dimensional, shaded images of design concepts on a color display and then quickly explore how major or minor changes affect the overall aesthetic impression. The system is completely interactive. By choosing from a menu on the screen, the designer can redefine display parameters, select a viewing orientation, or mix a color. Each part of an object can be assigned a surface type with associated color and reflectance properties. Built-in lighting controls generate realistic "highlights" on simulated surfaces composed of differing materials.

Before developing the system, David Warn, a computer scientist at the General Motors Research Laboratories, observed the complex lighting effects achieved in the studio of a professional photographer. By simulating these effects, Autocolor can produce results unattainable by conventional synthetic image display systems. Previous systems used a point source model of light, which allows adjustments only in position and brightness.

The versatility of the lighting controls constitutes a major advance in Autocolor. An unlimited number of light sources can be independently aimed at an object and the light concentration adjusted to simulate spotlight and floodlight effects. The lighting model even includes the large flaps or "barndoors" found on studio lights. These comprehensive controls permit the user to view the simulation in studio lighting conditions, as well as to make revisions in color, paint type, and materials.

With real lights, direction and concentration are produced by reflectors, lenses, and housings. It would be possible to model these components directly, but that would introduce considerable overhead to the lighting computation. Instead of modeling individual causes, Autocolor models the overall effect, reducing complexity by simulating those aspects needed to produce realistic results.

Autocolor approximates the geometric shape of an object with a mesh of three or four-sided polygons. These polygons are grouped to form parts. For a car body, there might be separate parts for the door, hood, roof, fender, and so on. Each part is assigned a surface type, such as painted metal or glass, and each type of surface has associated color and reflectance properties. The

entire data structure is stored in tables using an interactive relational data base developed at the GM Research Laboratories.

THE LIGHTING model determines the intensity of the reflected light that reaches the eye from a given point on the object. It takes into account the reflectance properties of the surface as well as the physics of light reflection. A hidden surface algorithm determines which point on the object is visible at each point on the display. For each of these visible points, the intensity is computed for each light source. The displayed intensity is the sum of the contributions from all the lights plus an ambient term which indicates the general level of illumination.

Using the point source lights of conventional image generation systems, highlighting a particular area of an object can be a difficult task and can result in unwanted highlights in other areas. By contrast, the light direction and concentration controls found in Autocolor make it possible to isolate the effect of a light to a particular area, and achieve a desired highlight easily and quickly (see Figure 2). This is not because Autocolor's lighting model computations are faster, but because its controlled "lights" behave in a more natural way.

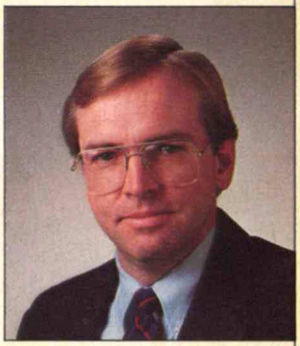
Another unique feature of Autocolor is the ability to portray realistically a variety of different materials and lighting conditions. The color seen from a surface is really a combination of two colors: the color of the surface or material itself (diffuse reflection) and the color of the reflected highlights (specular reflection). The highlight color may be the color of the material, the color of the light, or a color derived from the material and the light.

A different highlight color can be used for each different surface type that is defined. This makes it possible to simulate materials such as plastic, painted metal, and chrome—each of which has different reflectance properties and requires a different highlight color.

The user can interactively adjust the blending of the surface and highlight colors, watching the image change dynamically on the screen until a desired effect is achieved.

"Autocolor will free designers to be more creative," says researcher Warn. "Our goal is to move from controls that show changes in lighting, color, and materials, to software that will let the user change the actual shape, manipulating the image on the screen like a flexible clay model."

THE MAN BEHIND THE WORK



David Warn is a Senior Staff Research Scientist in the Computer Science Department at the General Motors Research Laboratories.

He received his undergraduate degree in mathematics from Carnegie-Mellon University, and his M.S. in computer science from Purdue.

He has done extensive research in relational data management systems with special emphasis on user interfaces and human factors. He also designed the prototype for the network data manager used in the GM Corporate Graphic System. His previous work on other aspects of computer-aided design include system design, file management, and simulation models.

His foremost research interests are in color synthetic image generation and interactive surface design. He joined General Motors in 1968.

U.S. Geology: Courting a Crisis?

BY CHARLES PETIT

Fewer and fewer U.S. earth scientists are traveling overseas to participate in Third World projects. This isolationism threatens American foreign policy and commercial interests.

About two years ago, a chance to gain scientific, diplomatic, and economic advantage knocked on America's door. A group of Indonesians contacted the United States Geological Survey, seeking somebody to put together a modern program to map resources and survey local geology for their country as part of a project paid for by the Asian Development Bank. By participating in such a project, the United States would not only create goodwill and reap the direct political dividends that accrue to nations that help out in the Third World. It would also make good business sense to get on board, as the hefty contracts for supplies and equipment for any new mining ventures that emerge from such programs tend to flow to the developed nations most closely involved. If the United States ever needed a critical resource that Indonesia could supply, the fact that this country had been a leader in maintaining earth sciences there could prove decisive. It is the sort of cooperative science project from which everybody benefits.

"It was embarassing," recalled John Reinemund, who has just retired as head of the survey's Office of International Geology. "We did not have anybody to send. . . . we are almost destitute of people with international experience." The Indonesians ultimately hired a Briton.

Earlier this year an American geologist traveling on private funds visited old friends in Peru, where he had worked 20 years ago as part of a U.S.-supported project. In the local mining journal *De Re Metallica* he saw a feature on a Japanese group that was helping the Peruvians develop ore deposits. Simultaneously, he learned, a French team was at work in the jungles of eastern Peru mapping 2.5-billion-year-old continental bedrock, and a British group had teamed with Peruvian counterparts to fill in geological voids in the Andes.

"Even the Russians were at work there," the geologist said. "But where were we? I guess I'd say [the Peruvians'] attitude was incredulous. They can't imagine a country as big and rich as the United States having nothing to do with the development of such a practical science around the world."

Such stories feed the conviction among many American geologists, especially those

ILLUSTRATIONS: MICHAEL CRAWFORD

Geologists fear that the nation's leaders will ignore the situation until a crisis hits.

who work with or for federal agencies, that this country has virtually abandoned its status of 20 years ago as the world's undisputed king of the geological mountain. "The United States is falling farther and farther behind in the minds of colleagues in other countries," Reinemund maintains, "and this is hurting our foreign policy in ways that may be hard to quantify, but that are real."

People in Reinemund's line of work worry that the practical skills of finding resources will erode, and that the personal friendships that grease the wheels of the international agreements assuring raw materials for industry will be lost. They fear that, with the world metals market awash in cheap ore, the nation's leadership will ignore the situation until a crisis hits—by which time all the easy cures will have gone glimmering like fool's gold in a miner's sluice. As scientists who study the earth, they fret that American geology will stagnate at a fundamental level for lack of exposure to the whole planet.

The reasons for America's apparent geologic isolationism are as diverse as the branches of the San Andreas fault. Beyond the overconfidence caused by the glut of strategic metals, they include: restrictions on travel for government-funded geologists, sparked by a Congress jealously guarding taxpayers' dollars; the fact that several federal agencies are focusing their missions more sharply, to the detriment of some areas of science such as geology; and the shift of funding priorities from civilian to military research projects. Geologists agree that the result will be more poorly educated members of the profession. "There is just no substitute for getting the feel of the land under your feet, and knocking off a few samples," says James Skehan, a Jesuit priest who directs Boston College's Weston Observatory. "The analogies between processes in different parts of the world just don't sink in very well if you can read only journal reports."

The most visible and official signal of distress comes from an 11-member task force appointed in 1981 by the Board of Earth Sciences of the National Research Council in the National Academy of Sciences. In the final drafts of its report, completed this spring and due for publication in the fall, the task force concluded that the United States displays a "surprising apathy" toward maintaining vigorous geologic activity around the world. Compared with other countries such as West Germany, France, Japan, the Soviet Union, and the United Kingdom, the panel said, the U.S. has failed to organize the geosciences to advance national interests, and in fact "has attained a subordinate position in this area during the past ten years."

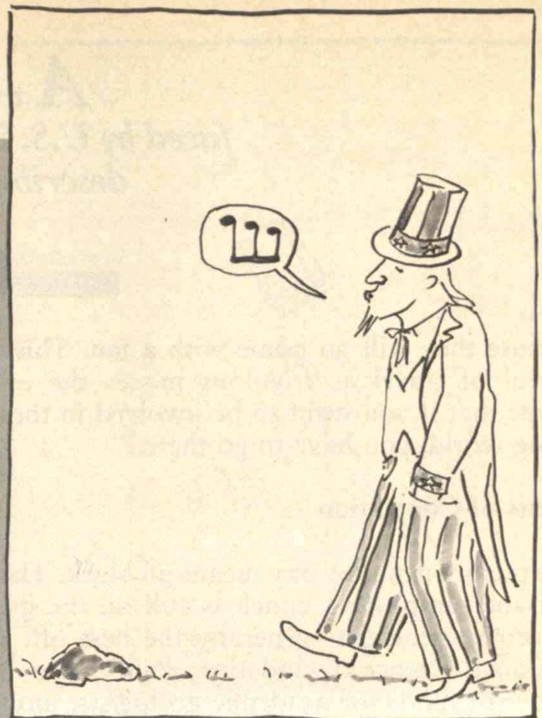
Earth sciences are vital to the welfare of any modern industrial nation, the report added. The panel called for overseas work to tap the technical and material sources of the developing countries through 'cooperative projects,' scientific exchanges, aid to their industrial firms in developing markets, and other indirect means. It said that the United States needs to awaken to the potential role of the geosciences in conducting foreign policy and advancing our economic interests overseas.

Certainly, geology is a science that turns rocks into money as well as a challenging field of intellectual study. The same line of inquiry that reveals the forces that shouldered the Andes, the Himalayas, and the Rockies skyward can also greatly simplify the job of prospecting within their folded strata for the metals and other minerals vital to industry. The eminent practicality of the field is why more than half of America's estimated 60,000 geologists find work with oil and minerals companies. Geology's time-honored status as a respected arena for scholarly endeavor, combined in an unusually direct fashion with enormous practical benefits, provides a double source of bafflement to geologists who see their colleagues in other advanced nations undertaking ambitious programs in international geology.

The Specter of Overseas Suppliers

Geologists are certain that if U.S. leaders don't get the message and pump a little money into cooperative government-to-government earth-science ventures, American industry and economic vigor will—to the extent that they rely on raw materials—be at the mercy of overseas suppliers who owe nothing to the United States. Recycling and rising industrial efficiency have somewhat reduced the U.S. appetite for new minerals. Generating a dollar of gross national product requires using up to 20 percent fewer minerals than a decade ago. Still, the nation is heavily in need of reliable supplies from all over the world.

"We've converted from a resource-self-sufficient



country to one dependent for most of its raw materials on imports, but the fact hasn't really sunk into the heads of government leaders, except in the case of petroleum," says Thomas Ovenshine, who took over Reinemund's USGS job earlier this year. "We are going to be a resource-importing country for a long time. What I am afraid of is that someday somebody is going to walk into the survey office here and ask what we have been doing to watch for alternatives to cobalt from Zaire, and we won't have an answer."

A look at this component of heat-resistant steel alloys is revealing. U.S. strategy to meet possible shortages of "strategic" minerals such as cobalt focuses on maintaining stockpiles of several years' worth of material in case of emergency. The most recent figures, for 1984, show the stockpile goal of 42,700 tons of cobalt is barely half met, and most other stockpiles are also below target. Furthermore, stockpiles can provide only a short-term buffer, at best, against future shortages.

No American cobalt mines have operated for 15 years, and some 95 percent of the 9,500 tons of cobalt the United States used in 1984 was imported. About 37 percent of American cobalt comes from Zaire, and another 12 percent from neighboring Zambia.

Ovenshine knows about Zaire. "I can tell you it is scary," he says. "They have one route to get the ore out, and that is along a narrow gauge railroad that looks like it's made of tin plate. All the power comes in on a line with poles you wouldn't use to hold up your TV antenna. Yet the ore is the most beautiful stuff in the world, basically a dolomite that is 5 percent copper with just a bit of cobalt. They make money on the copper; the cobalt is just a by-product. Yet we desperately need this one source."

The United States also imports 82 percent of its chromium, 99 percent of its manganese, 96 percent of its bauxite (for aluminum), and 74 percent of its nickel. The world is not about to run out of any of these materials, but as the Arab oil embargo of the early 1970s showed, America needs to broaden its base of supply as far as possible.

The United States has "economically depleted its resources," says Charles J. Johnson, an economist and geologist at the East-West Center on the edge of the lush campus of the University of Hawaii in Honolulu. In other words, mining cobalt here costs far more than buying it overseas. The overseas price has actually fallen by half, from about \$25 to \$12.50 per pound, since 1980. The prices of other strategic minerals are on similar tracks, said Johnson. "What is going to happen is a continuing shift for mineral sources to other countries, and putting tariffs—like Band-Aids—on the problem to protect domestic mines ain't gonna change that."

Johnson has spent a lot of time advising developing nations and visits about ten countries annually. He is now at work helping Zimbabwe overhaul its resource-assessment program. He is among many geologists worried by heavy U.S. mineral dependence on South Africa, whose mines supply much of America's chromium, vanadium, manganese, and platinum. That dependence restricts this country's room for maneuver in putting political and economic pressure on Pretoria to change its apartheid policies.

Johnson warns that cultivating alternate sources cannot be done casually. "We can't just drop off a geologist someplace like in the old days and expect good science and gratitude to come back. A resource-development package has to include not just some pure geologists, but people familiar with overall development strategies that fit into the needs of the host countries."

He adds, "One problem is, let's face it, that travel is fun, and many U.S. agencies frown on their employees using tax money to have fun. I have visitors on government business afraid to go to the beach

A worrisome problem faced by U.S. industry is the lack of maps describing resources around the world.

because they will go home with a tan. This disapproval of travel as frivolous misses the essential point: that if you want to be involved in the developing world, you have to go there."

Points of Contention

The picture is not by any means all bleak. The hammer-and-sample-bag bunch is still on the go, with university geologists generally the best off. At the National Science Foundation (NSF), the biggest source of funds for academic geologists, money for earth sciences has been going up a little faster than inflation in the past few years, with a $51.5 million budget requested in 1986 to follow the 1985 figure of $46 million.

U.S. geologists supported by NSF grants are probing the island arcs of the South Pacific, the incipient rifts of Antarctica, the 2.5-billion-year-old craton of Africa, the still-growing Tibetan plateau, and scores of other remote spots, typically working side-by-side with scientists from host nations. A new Geodynamics Program, sponsored by NASA, has drawn scientists from 25 nations into a cooperative effort to study the planet. The scientists use satellite-borne instruments to infer the internal structure of the earth, measure its magnetic and gravitational fields, plot the drift of continents with laser rangefinders, and monitor changes in rotation.

Clarence Allen, a noted seismologist at the California Institute of Technology and a member of the National Academy task force, says that "as many or more Americans seem to be at foreign meetings as ever." He adds that, like NASA, other agencies have begun important international earth-science efforts.

However, according to James Hays, the head of the NSF Division of Earth Sciences, "We're only doing relatively okay now because we did so badly in the late 60s and 70s, and a reason we did so badly then was that we never did receive funding that reflected the revolutionary insights of plate tectonics. By its nature this subject requires extensive study all over the world." Even the requested growth in this year's NSF geology budget is mostly for a single domestic program—an ambitious project to drill a sample hole 10 kilometers down into the basement of the southern Appalachians.

Furthermore, says Ovenshine at the USGS, "a university professor acts as an institute unto himself. He does research essentially to advance his own career, and he gets into and out of a country as fast as possible. He is not going to put together a long-term, directed program." Oil and minerals companies maintain their own exploration efforts, but such private programs usually focus on detailed mapping of known deposits and are often proprietary—results are not always published.

Thus, government geologists must bear the burden of maintaining U.S. familiarity with overseas resources. As recently as the 50s and early 60s, these geologists roamed the world by the score, leading cooperative programs to map geologic features, identify hazards, pinpoint potential resources, and generally put the United States in good stead with foreign leaders while providing a constant update on global resources. At one time, the U.S. Geological Survey was active in 70 nations.

While the USGS provided the workers, the State Department and the Agency for International Development (AID), as well as other development agencies, usually paid for the forays of 20 and 30 years ago. But for the past 15 years or so, AID science money has been funneled almost entirely into agricultural and health projects; no other major funding source has taken its place for government earth scientists. "Most U.S. agencies are set up by specific mandate to serve our national interests, but these interests are defined in such narrow terms that it is hard to show that international science qualifies," says Eugene Skolnikoff, director of M.I.T.'s Center for International Studies.

U.S. Failures

The National Academy panel, chaired by M.I.T. geologist B. Clark Burchfiel, ticks off a list of specific U.S. failures to keep pace with other developed nations in maintaining both basic geologic science and access to needed minerals:

☐ Policy pronouncements have been made, then ignored. These include the National Materials and Mineral Policy, Research and Development Act of 1980, which called on the president to "assess the opportunities for the United States to promote cooperative multilateral and bilateral agreements for materials development in foreign nations for the pur-

pose of increasing the reliability of materials supplies to the nation." The panel concluded that this act has not, to date, had any appreciable impact on policy.

□ Formal agreements supplemented by memoranda of understanding have been reached between U.S. agencies and foreign nations for geoscience cooperation, including agreements by the USGS with 27 nations. However, no money has been appropriated for most of these agreements, and the level of cooperative activity has therefore been minimal.

□ U.S. leadership in remote sensing [analysis of earth features from satellite data] is rapidly diminishing. This is partially a result of aggressive international competition, but it is also due to the fact that the United States increasingly favors military use of remote sensing equipment.

□ There is a "profound misunderstanding, even distrust, of international scientific 'entanglements' among some scientific program administrators and funding officials . . . The entire world is, indeed, the geologist's laboratory. Yet today, at a time when geology is burgeoning with opportunities for both pure and applied studies, we are using that laboratory less than we were 20 years ago."

□ One of the most worrisome problems faced by U.S. industry is the lack of available maps and information describing geology and resources around the world. The panel noted that the Geography and Map Division of the Library of Congress includes many geologic charts among the 50,000 maps it adds each year to its 3.7-million-map collection. However, no coordinated program exists to catalog and retrieve the maps efficiently—a service particularly needed by industry.

George E. Ericksen, who mans a desk at the USGS and is nearing retirement, is one of a diminishing number of veterans of major foreign geologic programs. He can proudly show off his Bernardo O'-Higgins medal, awarded to him with rank of knight commander by the government of Chile. "We went there with the purpose of getting the Chileans started in systematic geological investigation," he recalls. "In 1954, there were maybe four mining engineers and geologists in the whole country." Ericksen's group brought in geologists from Stanford and the University of California at Berkeley to begin a school of geology at the University of Chile in Santiago, and to set about the task of mapping the country's resources. He estimates that 75 native-born geologists still at work in Chile owe their start to the program.

Like most other U.S. geologists, Ericksen thinks that technical-assistance programs, particularly in earth sciences, are still useful to both the United States and developing countries, but they must be tended constantly. Even after indigenous geology programs are launched in poorer countries, he says, "they tend to get isolated without outside help, and science and technology in a poor country can easily take a back seat to other concerns. Suddenly, a country can find it is no longer capable of assessing its own resources." The academy panel found a more practical reason for the United States to stick with such programs: "If we no longer maintain a significant presence, our foreign competitors will have the market to themselves."

Mining, Modeling, and Ministries

There are many reasons why the United States is so lackadaisical about scouting the world for minerals, but at the top of almost everybody's list is the plain fact that the world mining industry is in a terrible slump; it is producing at well under capacity and has been for 10 years or so. American mining companies are in a particularly bad way. Robert C. Horton, director of the Bureau of Mines, reported recently that more than one-third of U.S. mining capacity is now idle, that 7 of 13 nonferrous mining companies lost money in 1983, and that few firms

Most government officials see a mineral glut around the world and say 'no problem.'

have any plans to increase domestic production. From 1972 to 1984, the number of American metal mines fell from 599 to 485.

Ironically, part of the reason for bad times in the mining business may well be the enormous rate of mineral discovery led by U.S. geologists in the fifties. "Most government officials," says Hatten S. Yoder, Jr., at the Carnegie Institution, "see that there is a mineral glut around the world, and say 'no problem.' However, when a problem develops, it's going to be pretty late to start worrying about a solution. Do you know how long it takes to get a site developed and in production? You figure you need 5 years of exploration and 15 to 25 years to get it going."

Ore prospecting is hardly the only practical reason geologists are anxious to travel. They also think they have a lot to say about geologic hazards such as quakes, eruptions, floods, droughts, climate shifts, and the growth of deserts that can have such immediate and often cruel effects on peoples. Even among geologists who think U. S. earth science is in pretty good shape, there is a feeling that government policymakers have a blind spot in this area.

"Global habitability, that is the key, and that is where geologists have so much to offer," says Kevin C. Burke, director of the Lunar and Planetary Institute located in the Johnson Manned Space Center complex near Houston. "A lot of this work has fallen into the hands of the meteorologists and the biomass people, who try to model the planet's behavior. But the world operates according to nonlinear processes that just can't be handled by any computer model. However, a good quaternary geologist can look at the record and tell you exactly what *did* happen in the past, and that can help us with the present and the future."

For whatever reason they are there, American researchers are always noticed when they work in small and less developed nations. The effect seems to be magnified for geologists. "Politically, the benefits of cooperation in geology may have vastly more weight than even the direct science benefits," says Farouk El-Baz, a man who sees geology from both a U.S. and a Third-World perspective. "Ministries of geology and mines and resources in smaller countries are of great importance, because they are the money makers." In other words, visiting geologists impress very important people in host nations.

Born in Egypt, El-Baz is vice-president for science and technology at Itek Optical Systems in Lexington, Mass. He designs methods for orbiting satellites to map variations on the earth's surface, and he led a pioneering project to map—by satellite-borne radar—surface features in his native Egypt that are covered in sand. Nonetheless, he fears that remote sensing is being pushed too hard and too fast as a high-tech substitute for "ground truth." "Even if you see something suspicious, somebody has to go out there with a Land Rover and see what is really there," El-Baz said. "Most of what we call remote sensing is still experimental."

El-Baz also thinks the national characteristics of his adopted country sell well overseas. "My colleagues are bowled over by the difference in working with Americans versus, for instance, Russians. When they ask a Russian a question, the answer is 'yes', or 'no,' and nothing else. The American, he is going to tell you everything he knows."

Some Institutional Solutions

Is there a solution to the crisis? The National Academy panel called in somewhat nebulous terms for creating an "institute for global and international geoscience" to act as a U.S. clearinghouse for information and policy discussion. Exactly what such an institute would do, and where in the U.S. government it would find a home, are left unstated. However, the panel recommended that funding come from both industry and government, and that agencies with a role in the institute include the State Department, the Department of the Interior, the USGS, NASA, and the NSF.

The panel's report also did not put a dollar figure on curing the ills of U.S. geology. But Reinemund, the former head of the USGS international geology office and a member of the committee, estimates that \$10 million per year would buy a "decent" international program, and that "for \$15 or \$20 million we'd have a tremendous program." He calls this amount "next to nothing" when compared with the current USGS budget of \$600 million.

The panel pointed to the Circum-Pacific Council for Energy and Mineral Resources as a potential model for its nebulously defined institute. The 13-year-old council focuses its efforts on the job of

bringing order out of the chaos of geological maps for the entire Pacific Basin. The aim is to provide a common set of maps—same colors, same coding, same scale, same projection—for this portion of the world. The program has completed more than half the 46-map series that, for the first time, will put on paper the dry-land and marine geology over more than half the globe.

Drawing largely on information donated by private industry and minerals ministries in 35 Pacific countries—including the United States, Japan, Australia, and the Soviet Union—the maps contain unprecedented detail on tectonics, geology, and resources ranging from oil to mid-ocean metal-sulfide deposits. "These maps are in great demand by the oil industry," said project director Warren O. Addicott, "and they show up all the time in scientific presentations."

The council is not an official or unofficial arm of the United States; its head, geologist Michel T. Halbouty, stresses its international character despite the central role played by Americans. But the academy panel calls the council's success as a forum for international earth-science cooperation a "pattern" for official U.S. emulation.

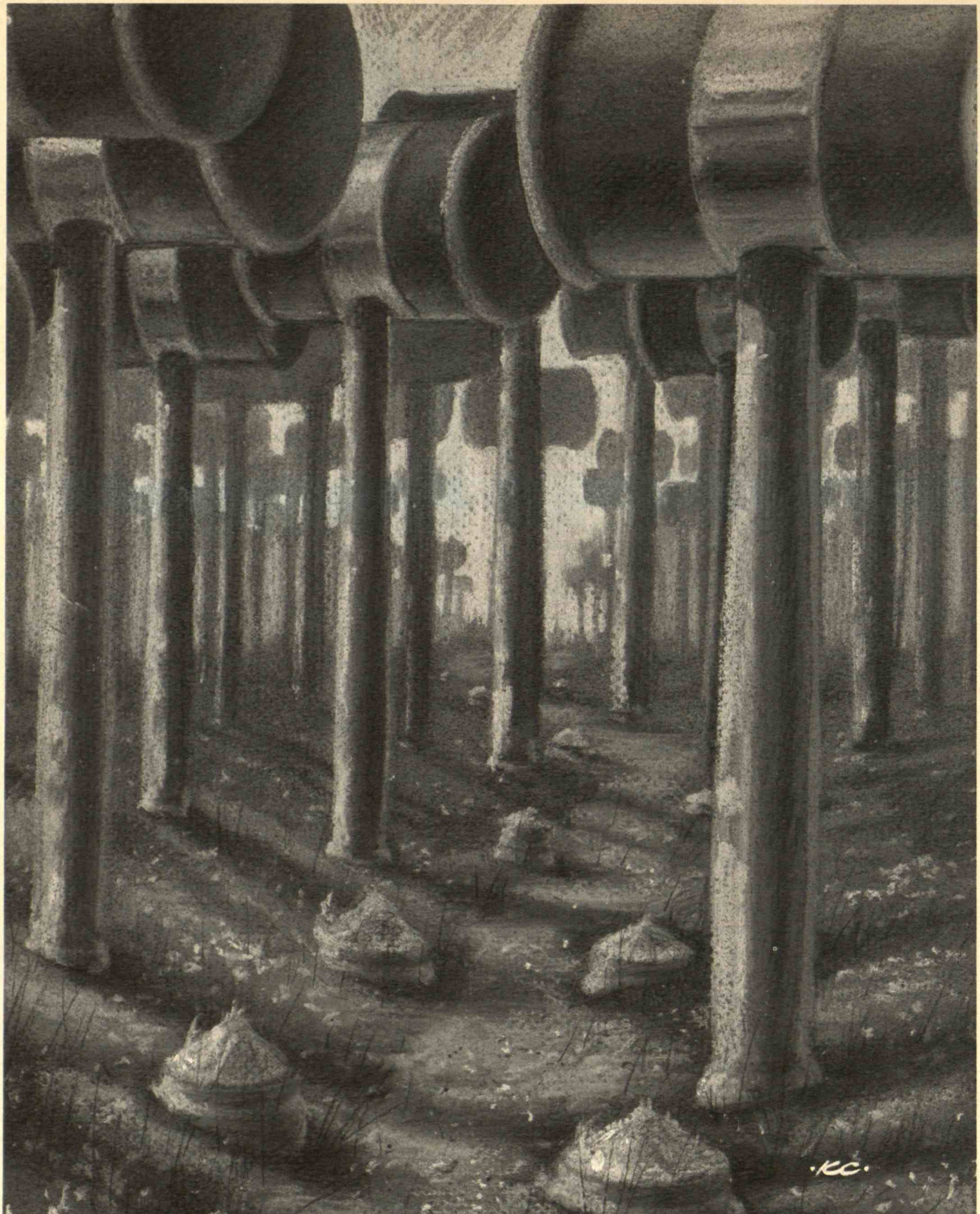
Halbouty got his start in the oil business as a high-school waterboy in the oil fields near his hometown of Beaumont, Tex., and talked the president of Texas A&M University into loaning him $50 so he could register to study geology there. Perhaps because of this background, he has a wildcatter's optimism that the United States will soon invigorate its international earth-science efforts. He has briefed the State Department on the Circum-Pacific Council and found that "they were amazed. They said that this council program is unique, and that it offers an unparalleled example of how much you can get done through international cooperation."

The current budget crunch in Washington dims the prospects that new programs will be funded almost to invisibility. Still, Halbouty says that "when everything has steadied down, I am confident that [Ronald Reagan] and his people are going to recognize the proper role of the United States in earth sciences." Geologists and other scientists are bouyed by a State Department program, strongly supported by Secretary George Schultz, to beef up contributions by science and technology programs to U.S. foreign policy. One foreign-service worker points out that "geology hasn't been singled out in any discussion I have heard, but it would seem to be exactly the sort of science that is being given new emphasis. It is a field with obvious economic benefits, which gives it a real advantage with this administration."

The angst that runs through the U.S. geologic community must be evaluated carefully. In particular, it is crucial to bear in mind that all geologists don't share the same problems. It is clear, from the rising chorus of complaint, that something is amiss, but the ailment is not really systemic. The academic quest for knowledge, for instance, seems reasonably well-nourished by agencies such as the National Science Foundation. The main problem lies in the practical side of international U.S. geology, and the need to keep a skilled cadre of geologists busy in cooperative programs overseas.

Establishing some sort of institute, with substantial dollar support from the industries that stand to benefit most from U.S. programs to help developing nations locate and assess resources would obviously help improve the situation. But Burchfiel, whose committee spent four years analyzing the problem, won't allow himself much optimism. "I would have to say I am not confident that a whole lot will happen. I've seen a lot of reports written, and most don't get anywhere beyond a spot on the shelf."

CHARLES PETIT is science correspondent for the San Francisco Chronicle. *He recently completed an academic year as a Bush fellow in science journalism at M.I.T.*



ILLUSTRATIONS: KEN CONDON

Clearing the Legal Path to Cooperative Research

BY LAWRENCE J. WHITE

MANY policymakers and industrial executives have loudly lamented the fact that the U.S. antitrust laws seem to scare high-technology companies away from entering cooperative-research agreements with their competitors. The specter of liability for treble damages if found guilty of anticompetitive practices has plainly dampened much of the enthusiasm for such ventures. Even when the Justice Department decided that it would not challenge the best-known research consortium—the group of 13 computer companies that banded together in 1983 to create the Microelectronics and Computer Technology Corp. (MCC), based in Austin, Tex.—such fears were scarcely quelled.

In retrospect, however, it is clear that the legal threat to collective research was never as great as feared—and even that small threat has been considerably reduced during the past year through changes in Justice Department policy and an act of Congress. Companies that consider entering cooperative-research agreements can never be totally assured that they will not be sued. But a close look at the antitrust laws, the Justice Department's enforcement of them, and the history of private suits reveals that the chances of a successful suit are quite small.

The question really becomes one of how great the benefits of collective research are likely to be. In my opinion, such projects can help U.S. manufacturers achieve modest gains in productivity. But the claims of the early 1980s—that collective research would be a major key to the nation's industrial competitiveness—will probably not be confirmed.

The legal barriers to cooperative research among high-technology companies are falling steadily. But will such projects really produce large dividends?

Gains and Losses

Under normal circumstances, competition among firms in an industry provides obvious social benefits. It can lead to lower prices, better service, more variety in quality levels, greater efficiency and lower costs in production, and larger output. All those benefits can also result from competition in research. However, under some conditions, cooperative research among a few or several institutions may provide greater social benefits than competition.

One obvious benefit is the economy of scale that can apply in areas where no one firm can realistically afford to do research. Industry associations such as the American Egg Board, the American Soybean Association and Development Fund, and the National Livestock and Meat Board fund research efforts that, though modest, are beyond the capabilities of most members of their industries.

Collective research can also reduce wasteful duplication of effort. If a research goal and the path to it are clear, for example, all efforts apart from the one that reaches the goal first go for naught. However, this is a complex issue. Often multiple research projects aimed at the same goal do not entirely overlap; they can, perhaps inadvertently, discover different things. Imagine, for example, that several firms are competing to discover oil. If there is only one pool of oil to be discovered, a single collective effort will likely be more efficient and less duplicative than a series of different drillings. But if multiple pools lie underground, the collective effort could well discover less oil and prove less efficient. The problem, of course, is that it is impossible to know beforehand how many pools exist—or how many good ideas can be discovered by research in a certain area.

Research is an inherently risky pursuit. It may consume large amounts of money without achieving the desired results. Collective research can allow several firms to share this risk—a motivation that seems to apply especially to microelectronics companies. Cooperative-research ventures can also capitalize on the complementary abilities of members' scientific staffs in a way that individual companies cannot.

However, collective research can also stifle competition. It may, for example, provide a vehicle for industry members to fix prices illegally (though the firms usually have plenty of other opportunities to do so if they are so inclined). Or it could enable firms to freeze out innovative or aggressively competitive mavericks by raising their costs of doing business.

An example of such behavior in an area related to research occurred three years ago. Hydrolevel Corp. of Farmingdale, N.Y., sued the American Society of Mechanical Engineers (ASME) because one of its standard-setting committees had implied that Hydrolevel's boiler cutoff devices were unsafe. Hydrolevel argued that a member firm influenced the ASME action because it feared competition from the new devices. Hydrolevel charged that by disparaging its devices, ASME was freezing Hydrolevel out of the market and thus raising its cost of selling the devices. Despite ASME's defense that it could not be held responsible for the actions of its officers and that, as a nonprofit body, it could not be sued, the Supreme Court ruled in favor of Hydrolevel.

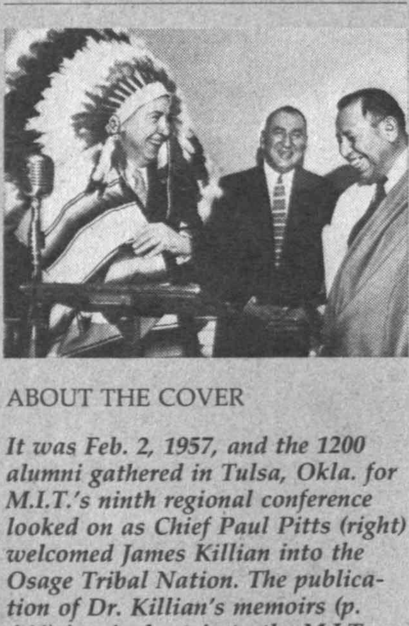
A group of firms in a cooperative-research venture may also try to slow down the pace of technological change—to reduce the uncertainties from new technology or to delay development of an unprofitable product. For example, in 1969 the Justice Department brought an antitrust suit against U.S. automakers, claiming that they had colluded to delay the development of pollution-control technology. At the time, emissions were not likely to be regulated until state and federal governments were convinced that the technology was available to control the emissions. The Justice Department charged that the auto

MIT

JULY 1985

MIT

JULY 1985



ABOUT THE COVER

It was Feb. 2, 1957, and the 1200 alumni gathered in Tulsa, Okla. for M.I.T.'s ninth regional conference looked on as Chief Paul Pitts (right) welcomed James Killian into the Osage Tribal Nation. The publication of Dr. Killian's memoirs (p. A11) inspired a trip to the M.I.T. Museum for this photo from the **Tulsa Tribune.**

DIANA BEN-AARON

Not Trying to Save the World; They Just Listen

"Hello, Nightline. This is Lisa speaking."
"What's the LSC movie tonight?"

One night about six years ago, Herb Lin, '73 met a woman at a party. She was a staffer at Harvard's Room 13 peer-counseling hotline and Lin, then a graduate student, decided M.I.T. could use a similar service. "Besides, I was doing my Ph.D. thesis in physics, and I needed a distraction from that," Lin said. He enlisted his friend Andy Adler, '79, and they began to plan the activity that would become one of the lowest-profile but most-used services at the Institute: Nightline.

It had been tried before: Don Collins, '69, had the idea for a student-to-student hotline when he was an undergraduate, but he was unable to get support for it. By the late 70s, the climate had changed. "We wondered if anyone would show up for the first meeting for people interested in staffing, but it filled a Student Center lounge," Adler recalled. "They just came out of the woodwork," Lin added.

Their friends from the Experimental Studies Group were the backbone of the group at first, said Lin. "The canonical staffer was an ESG member from Senior House or East Campus who folk danced occasionally."

"Hello, Nightline, this is Brian."
"Can you give me the number of a gay hotline?"

To Lin fell the task of shepherding the proposal through the bureaucracy. "We had to think about where to put the thing and who we were going to offend. For instance, one dean thought the deans did counseling and that was sufficient." Nightline tried to absorb the opposition by enlisting the deans to provide training and support for the staff.

Nightline also brought in guest speakers from the Samaritans (a suicide prevention organization), the M.I.T. chaplains, GAMIT (Gays at M.I.T.), Planned Parenthood, and Campus Police. "We wanted professional support, but the blind leading the blind was definitely part of the idea," Lin said.

Room 13 provided a precedent for the structure of the hotline. Room 13 had two volunteers, one male and one female, staying in one place from 7 A.M. to 7 P.M. to answer the phones, so Nightline did the same. Room 13 had about 30 staffers, each of whom worked twice a month, so Nightline did likewise.

But there was one difference: Nightline was designed to be an information resource as well. "Room 13 doesn't do information. They don't even have the newspaper," noted a staffer who has visited Room 13. "We wanted to keep a low threshold—you could call to ask what the LSC movie was and then ask other stuff. We also tried for a low threshold for staff—no intensive counseling or people who wanted to save the world," Lin said.

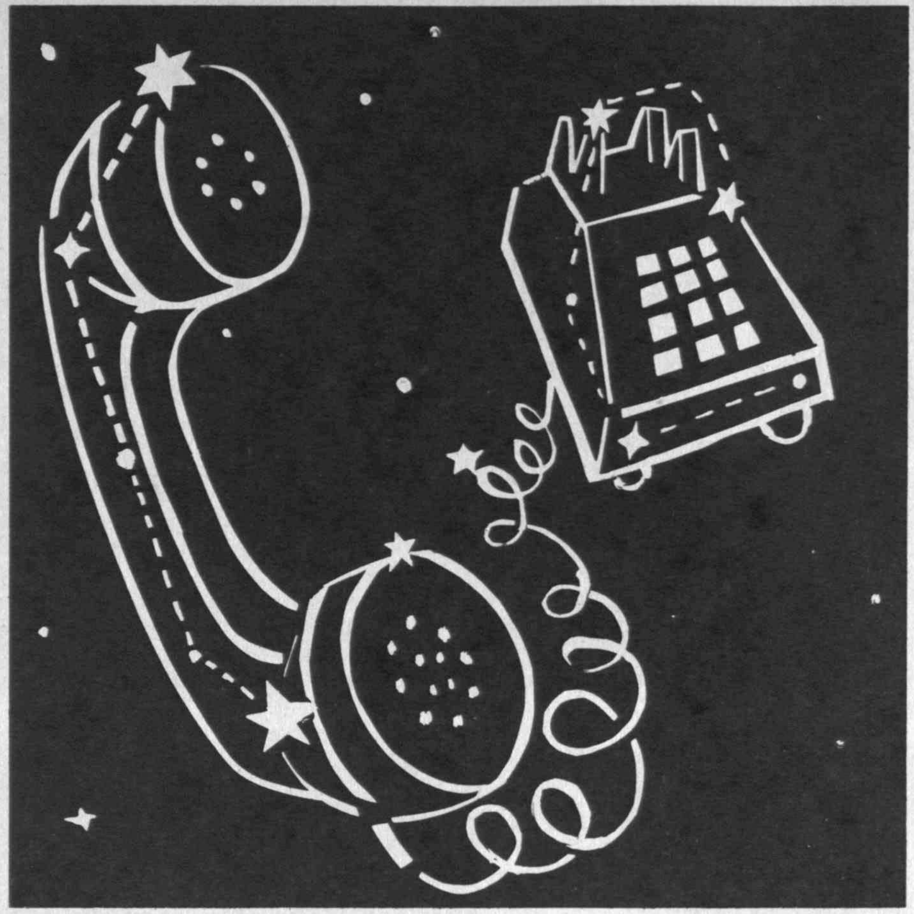
"Hello, Nightline."
"I think I'm failing a class . . ."

Lin and ESG director Dean Robert Halfman, '44, scoured the Institute for a suitable space. "In particular, we thought we might have drop-ins, and we didn't want it obvious that people were going to Nightline," Lin said. As it is, a turn-in near Ashdown, where it finally ended up, could be going any number of places."

"Finally in March 1979, I went to Paul Gray, who was chancellor, with the proposal," said Lin. "He said, 'This thing looks like it's already going. What do you need me for?' I said, 'We need money.' "

Nightline opened its doors on November 1, 1979, and Herb Lin went back to working on his thesis. "I sneaked past them a title page that said, 'Submitted

DIANA BEN-AARON, IMMEDIATE PAST EDITOR-IN-CHIEF OF THE TECH, PLANS A CAREER IN JOURNALISM WHEN SHE COMPLETES A DEGREE THIS SPRING.



the staffer. We look for people who are good listeners and can take suggestions themselves. We're not looking for skilled counselors, just for people who care."

While Nightline is able to absorb more than half of all interested students, Room 13 must turn away up to 150 a year. Lin believes the smaller response is due to the reduced role of activities at M.I.T. "We are busier here—the macho image is being four weeks behind two days into the term, not being involved in extracurriculars. It's how many grad courses you're taking as a sophomore."

"Hello, Nightline."
"So there really is a Nightline . . ."

(finally) in partial fulfillment of the requirements for the degree of Ph.D. in Physics.' " Lin never did serve on the staff, since there was in the early days a perception that graduate students and undergraduates were not peers. Nightline presently includes and takes calls from both graduates and undergraduates, however.

After studying science and education at University of Washington and arms control at Cornell, Lin is now back at M.I.T. as a postdoc in arms control studies. Adler, who majored in Course XXIVB—Language and Mind—is also working in Cambridge.

"Hello, Nightline."
"My roommate is driving me crazy . . ."

What is it like to staff Nightline? Each staffer spends two nights a month in the basement of Ashdown House. The room looks like a basement recreation room where children hold slumber parties. Part of it is a living room, with comfortable couches, bright posters, and newspapers on the coffee table. Beyond that, two room dividers conceal beds. At the back are a hot pot for making cocoa, a desk for studying, and an assortment of tired-looking armchairs, with a teddy bear sitting on one of them. "We call him Ted Koppel because people are always calling Nightline and asking to speak to Ted Koppel," a staffer said. (Ted Koppel is a N.Y. broadcaster with a program called "Nightline").

The heart of the operation is the phones, both on long cords that reach anywhere in the room. Staffers cultivate the ability to wake up from a dead sleep to orient themselves to someone's problem or find the answer to a complicated information question.

Among the resources at their disposal are bulletin boards layered with handwritten and clipped-out information: "PHONE NUMBERS: Samaritans, Dean on Call, Psych(iatrist) on Call, Room 13, Pizza Pad." "*Gay Community News* Quick Gay Guide to the Boston Area." "Hours of Alumni Pool." There is a bookcase with course catalogs, phone books, self-help books, medical references, and a CRC *Handbook of Chemistry and Physics*.

"Hello, Nightline."
"I think I might be pregnant . . ."

About 30 people a year sign up for Nightline interviews; the only requirment is that they be M.I.T. students and have been at M.I.T. for two terms. "That's to make sure they know their way around and can answer information questions," a staffer said. "When we interview them, we do role-plays—pretend calls, with them pretending to be

Nightline presently gets an average of seven calls a night, compared to 1.9 its first year. This is a very good response rate; Room 13, serving a community of similar size and pressures, only gets an average of two calls a night.

"When we aren't getting many calls and morale is low, we do a publicity campaign, and that seems to help," one of the chairman says. Last spring, for instance, they put up a pillar poster asking "What do you think of M.I.T.'s Nightline?" and got these responses:

☐ "I am lucky enough to live in a close, supportive living group, surrounded by friends I can turn to or just BS with. Nonetheless, even I have had occasion to use Nightline. I can just imagine how great it must be for the alienated."

☐ "Nightline is OK, but they should have more phone books and they should have the schedule of Joe's Pizza Truck."

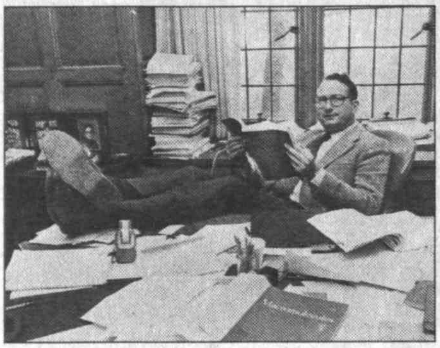
☐ "I've called it . . . don't get rid of it. It is maybe the one thing that helps ease the pressure. If this goes, what goes next—four-day weekends? We're under so much pressure sometimes we think we'll crack—and Nightline helps."

☐ "I am very pleased to see that Nightline has survived and apparently prospered since its inception in 1978. . . . It's enough to warm a cynic's heart."—Herb Lin, Nightline Founder

"Hello, Nightline."

ILLUSTRATION: ELIZABETH SLOTE

Meet John Deutch, Provost



"Extremely intelligent . . . brutally blunt . . . open and accessible. ."

A deep "ha-HAH!" reverberates wall to wall in the du Pont tennis courts, and the intensity and pleasure in that shot are unmistakable. They are noteworthy dimensions of John Deutch, '61, a man more often cited for awesome intelligence in the context of his work with Robert McNamara in the Kennedy Administration, or for his rapid rise from newcomer to second in command in Jimmy Carter's Department of Energy, than his zeal for racquet sports.

Later, looking at the photographer's contact sheets from that game, one sees that Deutch plays tennis with very good form. There are no moments when the camera catches him off guard. Across the net are his 14-year-old son and Professor John Hopfield from Caltech. Deutch's partner is Hopfield's daughter. There is no condescension to the young players—the serves are hard, the returns skim the net into tight corners. It is assumed that the kids will cope with a challenging situation . . . the M.I.T. experience extended to the court.

That was a Saturday morning in May, almost two months before John Deutch, then dean of science, was to take office as the new provost of M.I.T. Already there were announcements and interviews in various campus publications, a strong track record and a wide network of associates in academic and government circles, and any number of squash and tennis games pointing to the leadership style the Institute can expect.

Priority: Undergraduate Experience

The most significant of these signals came in February, when Deutch announced two appointments designed to fulfill one of his first priorities: improvement in the undergraduate educational experience.

Samuel Jay Keyser, most recently head of the Department of Linguistics and Philosophy and director of the Center for Cognitive Science, was named associate provost for educational policy and programs; and Margaret L.A. MacVicar, '65, Cecil and Ida Green Professor of Education, professor of physical science, and director of the Undergraduate Research Opportunities Program (UROP), became M.I.T.'s first dean for undergraduate education.

At the same time, Deutch announced his intention to place the dean for student affairs in the Office of the Associate Provost for Educational Policy and Programs, a signal that M.I.T. recognizes how strongly the living environment affects students' educational experience. Also to be placed in that office, along with the new dean for undergraduate education, is the dean of the Graduate School, which makes possible an integrated overview of M.I.T.'s entire educational program.

According to a mission statement that accompanied Deutch's announcement, the process of change will be broken into four stages: assessment of the education M.I.T. is providing now, followed by planning, implementing, and evaluating the new programs and policies. The process may take as long as ten years and will require a commitment of resources to support educational innovation. The program is characterized as "one of the most important moves in the recent history of M.I.T." by William Hecht, '61, executive vice-president of the Alumni Association.

Deutch always highlighted the undergraduate program in the lists of annual objectives he drafted as dean of science.

"I think there is a general feeling that we need to strengthen undergraduate education; that view arises in almost all elements of the community," Deutch said in a late-winter interview. "There is a concern about the quality of life, concern about how well we have understood the complete education of the students in the sense of both the classroom experience and the experience outside the classroom . . . There is concern for the content of the subject matter which is presented, especially in the freshman year. There is a strong interest, which I share, in seeing that our undergraduates, especially those who major in science or engineering, have a more profound exposure to the humanities and social sciences," he said.

"It's not that I enter the position of provost with a certainty about exactly what changes are necessary," Deutch cautioned. "But to me, it's absolutely clear that people are uncomfortable and want to be given the opportunity for change."

Need to Reduce Salary Recovery

As Deutch settles into his new post, it is likely that other themes from his tenure as dean of science will continue to be important: stimulating cooperation between the Schools of Science and Engineering, particularly through the interdisciplinary laboratories; reducing costs that must be charged to research sponsors; continuing efforts to hire more women and minority faculty members; and strategic planning to guide the allocation of resources.

Deutch is particularly pleased with the the School of Science's success in curtailing the need for junior faculty to raise portions of their own salaries. "When faculty must seek a significant fraction of their own salaries and research support, their loyalty to the in-

PHOTO: PETER MUI, '82

Margaret L.A. MacVicar and Samuel Jay Keyser are two of the key appointments in John Deutch's reorganization of the Provost's Office to put greater emphasis on the undergraduate program. Prof. MacVicar is M.I.T.'s first dean for undergraduate education. She is one of several deans who will be part of the Office of the Associate Provost for Educational Policy and programs, a post now filled by Prof. Keyser.

stitution and their commitment to undergraduate education is weakened. It impairs their choice of research problems and the quality of life they lead," Deutch says. "I might add that there is a competitive aspect to this problem: by reducing the need to cover academic salaries through research support, we help ensure that the price we must charge sponsors for research is not significantly higher than that charged by the other private universities that are our competitors."

Moving into Public Policy

Deutch's own career has been a fruitful melding of science with social science. He attended both Amherst and M.I.T. as an undergraduate, under a five-year joint program of study, receiving in 1961 bachelor's degrees in history and economics from Amherst and in chemical engineering from M.I.T.

One result of that combination of specialities has been noted by Amherst Professor Emeritus Willard Thorp. Thorp is a former director of the Merrill Center for Economics that Amherst operates in Southampton, N.Y., where Deutch spent a memorable summer after his junior year. Quoted in the Amherst alumni magazine, Thorp remembers Deutch as a "very brilliant student. He had some necessary mathematical abilities that were only beginning to be required then."

Deutch took his unusual background in economics and applied science to Washington in 1961, and for the next four years he led a double life: as one of the "whiz kids" in the systems-analysis group that brought civilian control and computer modeling to the Defense Department under McNamara and as a graduate student pursuing a doctorate in physical chemistry at M.I.T. That pattern—of moving readily between government agencies and the academic research community—has remained a hallmark of Deutch's career.

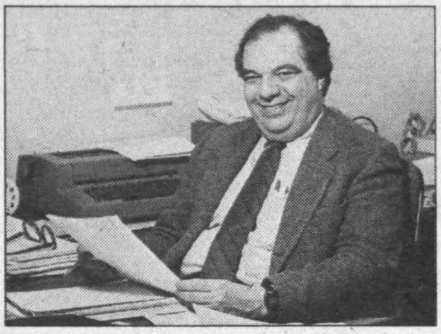
Following a post-doctoral year at the National Bureau of Standards, Deutch joined the chemistry faculty at Princeton. He returned to M.I.T. as associate professor of chemistry in 1970. He was head of the chemistry department by 1977, when James Schlesinger persuaded him to return to Washington to serve as the first director of energy research in the newly formed Department of Energy. Deutch quickly became acting assistant secretary for energy technology, then undersecretary.

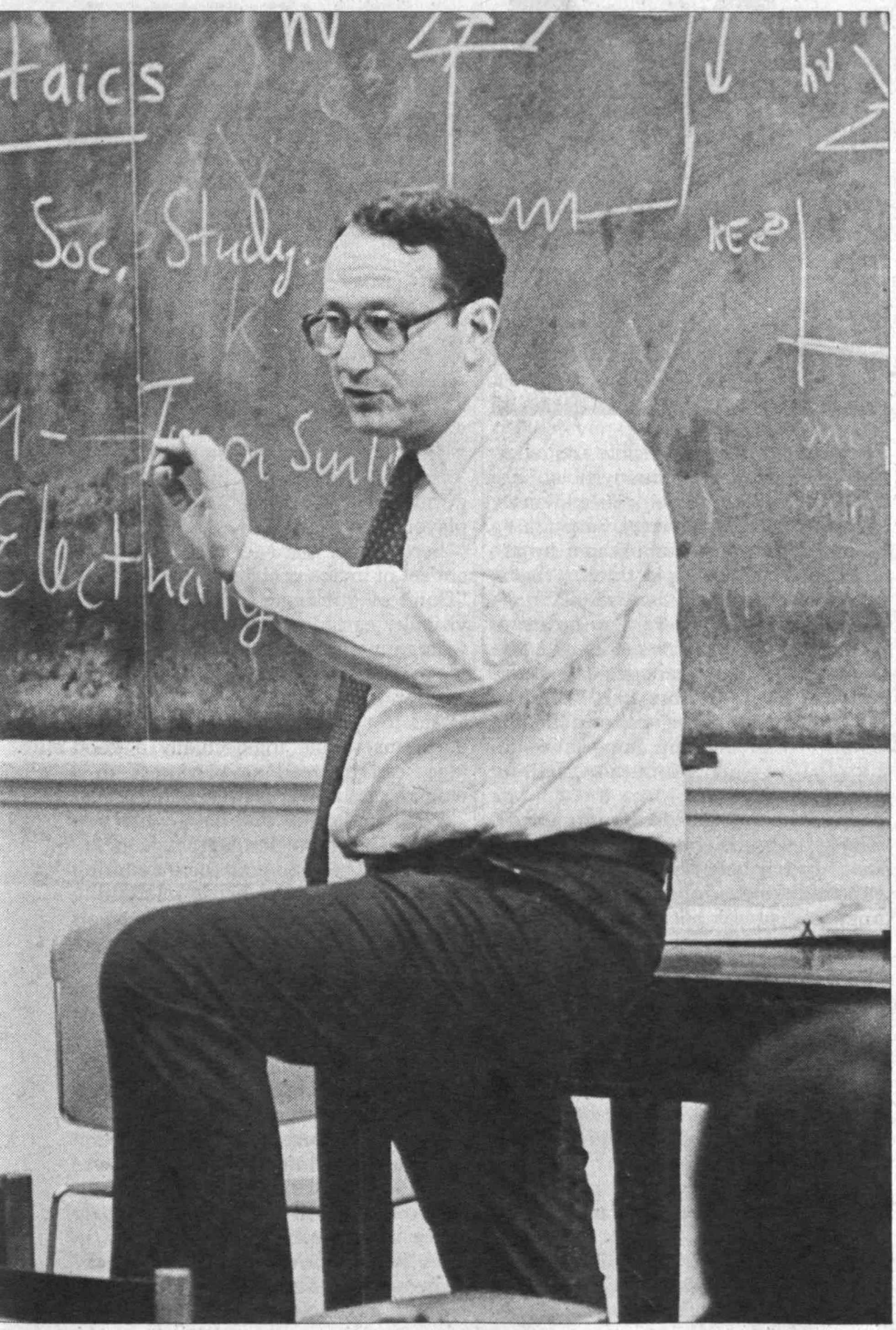
Deutch was the focus of considerable media attention in his DOE posts. That's not surprising, since one of his responsibilities was the management of nuclear waste, described by an aide as "one of the most polarized issues in Washington at that time." Deutch was characterized as a "nuclear technocrat" by Boston journalist Rory O'Connor in a thoughtful article in *The Real Paper*, a now defunct alternate newspaper published in Cambridge. O'Connor presented nuclear power as a "technological Vietnam," and he was not disposed to treat Deutch gently.

O'Connor noted that Deutch's appointment to head the energy research effort was acclaimed by the scientific/technical community, that he had strong ties with industry, and that he got high marks from the military and intelligence communities. At the same time, O'Connor observed, Deutch was also highly regarded by public-interest groups such as the National Resources Defense Council and Ralph Nader's Critical Mass Organization. A lobbyist for the latter was quoted as saying that Deutch was "extremely intelligent and brutally blunt," as well as being "probably one of the most open, accessible officials in DOE."

Deutch returned to M.I.T. in 1980, and two years later was named Dean of Science, while continuing in an advisory capacity with many public agencies. At the request of President Carter, he served on the Nuclear Safety Oversight Committee, and in 1983 President Reagan appointed him to the Commission on Strategic Forces, headed by Lt. General Brent Scowcroft.

As a chemist, Deutch is recognized as an authority on non-equilibrium statis-





tical mechanics, the structure of fluids, dielectric and magnetic relaxation, light scattering, and polymer physical chemistry. He is the author or co-author of more than 120 technical articles.

No Letup in Teaching and Research

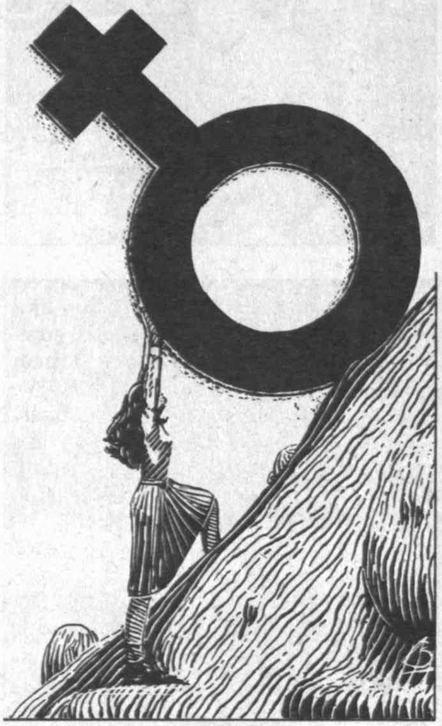
He continues to teach and conduct research: "There is no way to persuade me to give it up," he says. Next year he will teach a class in modern polymer science jointly with Professor Ulrich Suter of chemical engineering, and he expects that both faculty members will learn as much as the students.

That seems to corroborate the statement by former aide Kevin Gorman that "the remarkable thing about John Deutch is his ability to keep ten balls in the air at once." Gorman was Deutch's executive assistant for two years at DOE, where he found that his boss was also able to avoid the pitfalls of isolation that often come with rank. He describes Deutch as "people-oriented"—sensitive to the human interactions around him, whether they involve opposition members of Congress or his own support staff. "Most constituency groups at M.I.T. will find that they have John's ear," Gorman predicts.

For all his impeccable management credentials, Deutch says, "I think that everyone knows that my style as provost will be to rely heavily on the deans and associate provosts for the execution of programs. That is how one does best, especially at a place like M.I.T., where ultimately our strength comes from delegating responsibility for the management and execution of programs to an appropriate level."

What else should you know about John Deutch? He has three sons, one at Amherst, one at Colby, and one in junior high school in Lexington, and his time with them is very important. He has a home on Cape Cod, enjoys consulting for industry and visiting with friends in Washington. And his continuing ambition is to beat Gerry Wilson (dean of engineering) at squash.—*Susan Lewis* □

PHOTOS: CALVIN CAMPBELL, KEN FLOWERS, '86



Women at Work: Battles Not Over

The themes were not new: the pitfalls of management and of technical career paths, the special hurdles for women and other non-traditional professionals, and the challenge of gaining a toe-hold in a new job.

But they had special meaning for the more than 200 women who attended the fifth annual Career Conference held by the Association of M.I.T. Alumnae (AMITA) and the Boston chapter of the Society of Women Engineers (SWE). For some of them may well be the first of their sex to wield responsibility in their organizations. Even today, there are few role models and colleagues at hand. The AMITA/SWE conference is their major opportunity to share the accumulated wisdom of similarly educated and motivated women.

Dual Ladders Not Working

In her studies of career paths in corporations, keynote speaker Lotte Bailyn found "very few senior engineers who are still productive and happy." Pressured to develop deep, narrow skills, they grow bored, according to Bailyn, a professor of organizational psychology at the Sloan School. Companies with dual ladders "have to make the (technical) projects more challenging as well as making the salaries higher," she said.

At the same time, engineering is typically seen as a mere chrysalis from which to emerge into management, Bailyn said. She suggested that engineers who plan careers in research and development join university or government research labs or seek academic posts. These are areas where "there's still a pull toward management, but it's not felt to be the only way to be a success."

While universities usually accommodate more diversity than do corporations, women in academe are often merely tolerated. Some women are called upon to be over-visible and overworked, while others are invisible. Students and colleagues do not see them as well-connected or powerful, Bailyn said, and the problem is complicated by affirmative action. People think, "that's the only reason she's there at all."

For those who do want to be managers, the key to future success is early promotion to the management track. Performance indicators like ambition and numbers of hours spent on the job assume overwhelming importance in the race for each promotion, Bailyn found.

And who is likely to be promoted? "The people who were successful in the past," Bailyn believes, "—white males with traditional support systems." The prognosis is bleak both for women and for men in two-career families and applies to both engineering and management: "Women now have two ladders they're not moving up."

And if they do approach upper management, women are still seen as potential trouble makers. Several conference participants told of women being advised to take feminist activities—even SWE—off their resumes.

Starting Out On the Fast Track

If reality is sobering for women in general and women engineers in particular, that just increases the pressure not to make a misstep, from the first day on the job. That was the message from a workshop offered by Lita Nelsen, '64 (president of AMITA for 1984-85) and Christine Jansen, '63.

"If your company thinks you are a winner, they will give you the most important assignments, expect the best, predict the best, give you the most visibility, and give you the most cooperation." In other words, they will make you a winner, according to Nelsen, who is president of University Seminar Center, and Jansen, a manufacturing manager at Digital Equipment Corp.

The key to getting started as a winner is preserving the image you build up in your interviews. "You may come in as a winner, but once someone decides you 'don't have the right image,' 'aren't good with people,' 'aren't a team player,' you're dead."

Becoming a manager means a different set of image problems, Nelsen said. "Don't overdelegate at first. You need visibility early in the game." What the woman manager does not need is people asking whether a man is doing the job for her. "Another trap is, 'She's afraid to speak in public.' And asking questions, while intellectually a good idea, can be read as weakness in a woman manager," Nelsen noted.

What if the job just isn't what you expected? "The technology is years behind what they told you; there's a hiring freeze and you have to do everything yourself; you are reporting two levels lower in the hierarchy than you were when you accepted the job. Sometimes they want you so much they lie about it all," said Nelsen. If this happens, present your complaint once or twice, and then start quietly looking for a new job.

Nelsen and Jansen predict trouble in any job where you are expected to live up to your predecessor. One participant told of walking into a job where she was introduced as "Hi, this is Andrea. She's the new Arlene." Arlene's files took up every inch of space in Andrea's new office. Nelsen and Jansen's advice? "Throw out the files, Andrea. Give yourself a fresh start." *Diana ben-Aaron*

ILLUSTRATION: CHRIS BING

AMITA and BAMIT are not just noise in the system, but voices that raise legitimate concerns of the under-represented.

M.F. Wagley

AA President Sees Minorities and Women as M.I.T. Priorities

Mary Frances Wagley, '47, punctuated her year as the first woman president of the M.I.T. Alumni Association with an address to her fellow members of the Corporation. This speech brought together the themes of her tenure as president, and we print a very condensed version below.

I want to do three things: first, to make some general comments about the Alumni Association; second, to share some observations about women at the Institute; and finally, to anticipate some concerns which affect both the Corporation and the Association.

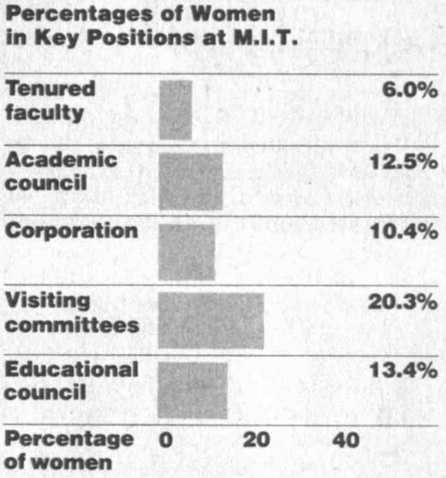
First, the Association itself. It is well to remember that, collectively, we are relatively young. Over 50 percent of the M.I.T. degrees have been granted since 1961. Three-fourths of the 6,000 M.I.T. women have graduated in the last two decades. Our relative youth has ramifications with respect to fund-raising, reunions, club and other activities and should be kept in mind when we compare ourselves with our chosen peer group—the Ivys plus Stanford. We should also note we are geographically scattered. Seven thousand alumni live outside the U.S.A., 8,000 reside in California, and between 8,000 and 9,000 in the New York-Metropolitan area.

While our 80,000 alumni include 60 percent who earned bachelor's degrees at M.I.T., the picture is changing. Today, 60 percent of the degrees awarded are graduate degrees. In the future, this will have an impact on what we can expect to do with and for our alumni.

Whatever the activities of the Association, fund raising is always on the agenda. The goal of the annual fund this year, fiscal '85, is $10 million, but total gifts from alumni are about twice the annual fund. This apparent anomaly arises, partly, from the fact that the Alumni Fund counts only gifts from living alumni (no bequests) and records only gifts under $50,000, or the first $50,000 of larger gifts. When we compare our results with those of the Ivys-plus-Stanford in percentage of participation, we rank third. We rate less well when it comes to size of the median gift, and it is our goal to raise this figure.

I should mention here that we have two special purpose Alumni Associations, AMITA and BAMIT. The first is the organization for women alumnae and the second is the Black Alumni of M.I.T. You may wonder why and if these are necessary. I did prior to this year. But I have come to see that AMITA and BAMIT are not just "noise in the system," but voices that raise legitimte concerns of the under-represented—voices which must be heeded.

M.I.T. cannot afford to relax its efforts with respect to women students. It is not only right to offer girls the educational opportunties M.I.T. presents; it is pragmatic, as well. Over the next decade the young adult population will decline by more than 20 percent nationally and by as much as 40 percent in New England. M.I.T cannot afford to fish in only half



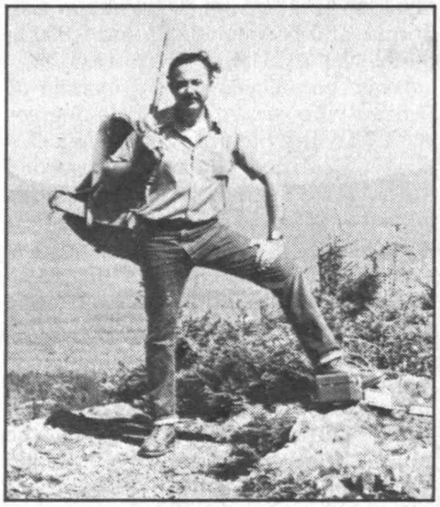
the pond.

If the population of women students is to increase, so must the numbers of women in (faculty and high administrative) positions. If it does not, a hospitable climate will fail to materialize and fewer girls will elect to come to M.I.T. As yet, women are under-represented in key positions, as you can see from the accompanying chart.

When these figures begin to match the student figures, I think you will see AMITA begin to question the need for its own existence. I suspect the same may be said of BAMIT and the presence of minorities in key positions.

☐ A final speculation. As M.I.T. enrolls more and more women students and employs increasing numbers of women at faculty and administrative levels, I believe that they will ask the Institute to pay attention to the conditions of secretaries, administrative assistants, lab technicians, etc., who are usually women. I do not imply a lack of concern now. The new director of personnel started her M.I.T. career as a secretary 12 years ago. That's marvelous. I am saying that this cannot be an isolated instance anymore than my Alumni Association presidency can long remain unique. ☐

PHOTO: MARIO SCATTOLONI; DIAGRAM: OMNIGRAPHICS



Even for successful engineers, life is enriched by activities outside work. For the late Jim Cunningham, that might mean a hike up Chairback Mt., Maine; for Cunningham Scholarship recipient Linda Zelinka, it is often volleyball with friends from the AI Laboratory.

Cunningham's Legacy Lives

James Draper, '63, expected that asking people to give money would be an ordeal. It was, however, the best way to establish a memorial to his old friend and fraternity brother, James Cunningham, '57. As the only member of the grieving assembly at JC's funeral in Dallas who lived in the Cambridge area, he was the logical leader for such a project.

In the process of honoring Cunningham's memory, Draper discovered a new repertoire of skills, established a deep bond with fellow graduates, and came to know a talented student.

Jim Cunningham's character was central to the efforts of his friends. After earning a first degree in geophysics, he stayed a fixture at the Beta Theta Phi house while working towards the Sc.D. in electrical engineering he received in 1963. Draper remembers him as a "father confessor," who helped the younger brothers survive technical (and personal) problem sets.

Cunningham's thesis on image transmission was the foundation of his first business venture, Electronic Image Systems, Inc., a company which participated in transmitting the first full-color earth photographs from satellites. Cunningham subsequently helped form IMLAC Corp., Needham, Mass., before moving to Dallas as vice-president of engineering and director of product research for Docutel.

Cunningham was an enthusiastic alumnus. He served his class as treasurer, 15th reunion chairman, president, and fund raiser. Diagnosed as suffering from leukemia in 1978, he turned some of his attention to cancer support groups in the Dallas area. Illness did not keep JC from his 25th reunion in 1982.

When Cunningham died in January, 1983, Draper and his fellow mourners decided that he left a legacy of excellence in his work as an engineer that would be best vested in a scholarship. Ultimately, it was Draper who had to bite the bullet, get on the phone, and ask for money. "Human communication," he notes "is not a skill made much of in the M.I.T. syllabus," and he was gloomy at the prospect. The commitment from JC's family and friends and from the M.I.T. connections—in emotional support and cash—was immediate. Draper found that Woody Allen is right: "Eighty percent of success is showing up."

Tens of thousands of dollars rolled in by mid-summer, including a matching grant of up to $50,000, and attention turned to dispensing the money. "There is at M.I.T. a catalog of scholarships thick enough to prop up any number of wobbling tables at Jake Wirth's," as Draper says. "In the parlance of the M.I.T. Enterprise Forum, what we sought for our new enterprise was a limitless market with no competition. Quite surprisingly, we found it in setting up M.I.T.'s first scholarship for women in engineering."

Enter Linda Zelinka, who was chosen to receive the first award in the fall of 1983. Now a senior in Course VI-A, she has been an intern at General Electric in Schenectady since her sophomore year. Through UROP, she has been a programmers's apprentice in the Artificial Intelligence Laboratory since the second semester of her freshman year. Zelinka embodied the required high standard in engineering, and, as a person, she's a donor's delight.

"I always wanted to be here," Zelinka says, "but my mother was afraid that we could never afford M.I.T." But M.I.T.'s financial aid package brought her goal within reach.

She considers herself "lucky," because doing computer science proved to be just as engaging as she imagined it would be. And there are surprises, like being treated as a colleague rather than a "mere" student by the professionals at G.E., where she works on automatic theorem proving and programming environments.

Both the AI Lab and her floor at McCormick provide a steady supply of intramural teammates for the basketball, volleyball, and baseball she loves. And the Tech Catholic Community, Zelinka's spiritual home on campus, welcomed her creation of monthly calendars, each one a totally different visual design.

Having lunch with Linda for the first time, Draper realized that a scholarship for women not only enhanced the careers of the recipients, it also served the engineering profession. He believes that American industry must utilize fully the potential of women engineers if it is serious about staying competitive internationally.

He and fellow fund raisers are still at work. With $90,000 raised so far, and the base widened to include the Association of M.I.T. Alumnae (AMITA) and other special supporters of women, efforts are well underway to establish a second Cunningham Scholarship in Aeronautics and Astronautics.

Draper has confirmed that even as alumni, M.I.T.'s progeny are pushed to reach beyond their grasp . . . and they learn to like it.—*Susan Lewis* □

PHOTOS: FRANK REVI, '86; JAMES S. DRAPER, '63

Killian's Era: Years of Challenge Lived with Verve

For almost all of the last 60 years M.I.T. has been his place of work and focus, and always it has been his passion. For 32 of those years he occupied the offices reserved for the Institute's leaders. No one else has served the Institute at this high level of leadership for so long, and no one—save perhaps its founder—has left a comparable mark.

These extravagances lie just beneath surface, running like a Gulf Stream under the memoir of James R. Killian, Jr., '26—*The Education of a College President*—published by the M.I.T. Press in May. Above that current are Killian's accounts of all the events of those 60 years and of the people with whom he shared them—a chronicle reconstructed from memory, papers, and patient research and told in his graceful and abundant style. Unmistakably Killian.

Almost every graduate of the Institute will find events in which he or she shared—but within them details and even perspective that are new and unexpected. History given new meaning, people transformed into legends.

Killian came to M.I.T. to study textile engineering because it ran in his family. Three times he nearly left: once upon graduation, when he had offers from industry, as well as from *Technology Review*; once just after World War II, when he could have become general manager of the new Atomic Energy Commission; and once in 1948 when offered the presidency of a major university in the southeast. He turned down the AEC job when he realized it would hold him prisoner—"impaled on a moral quandry" about the nation's nuclear future. And he turned down the university presidency when Karl T. Compton, to whom Killian was vice-president, suggested a rearrangement of the executive office—Compton as chairman of the Corporation, Killian as president.

No American university president has had a more dramatic inauguration—a convocation of world scholars with Winston Churchill and Harry Truman invited to be keynote speakers. (Truman backed out at the last minute, and Killian himself called Harold Stassen, then president of the University of Pennsylvania, to take Truman's place.) Only the Boston Garden with 14,000 seats would accommodate the crowds who wanted to hear Churchill. Yet when Killian went to the Ritz Carlton to escort Churchill to the Garden, he found the former prime minister anxious for reassurance. His speech, he said, had been "a labor of

A clock that ran backward, promising "eternal youth," was the gift of the Class of 1911 to James R. Killian, Jr. '26, on its 50th reunion. Little did they know: since his retirement as chairman of the Corporation, Killian has been chiefly engaged by what he calls "the rapture of the backward view," writing memoirs of his 60 years at M.I.T. With Killian at Technology Day, 1961, were Howard D. Williams, '11, and Catherine Stratton.

PHOTO: M.I.T. MUSEUM

great difficulty." But confidence soon enough returned. By the time he stepped out of the Ritz elevator Churchill had found a cigar and held aloft his famous "V" for victory, and in the limousine there was a scramble for the dome light switch so that Churchill could be seen by crowds lining the streets.

Killian's introduction to the bureaucracy of M.I.T. came when, as editor of *The Tech*, he wrote an editorial in November 1925 on M.I.T.'s then-declining enrollment; shortly thereafter, hired by *Technology Review* as its junior editor, Killian found himself moonlighting for the president's office, writing brochures to tell high school students about the virtues of "Boston Tech." A few years later he organized what is now the M.I.T. Press, and—as treasurer of the Alumni Association—he helped launch the M.I.T. Alumni Fund soon after Compton became president.

The move from the *Review* to the President's Office came in 1939, when Vannevar Bush, '16, left the vice-presidency of M.I.T. to join the Carnegie Institution of Washington. Bush recommended Killian, then 34, to be executive assistant to President Karl Compton. Within the same year Compton became a partner with Bush and others in organizing the National Defense Research Committee to mobilize U.S. scientific resources against the Nazis, and Killian found himself—though "still a puppy and not yet housebroken"—taking new responsibilities every day. He still remembers "moments of insecurity and considerable doubt that I was cut out for the job."

Left "Dangling in the Breeze"

Not to worry. He loaned money to students when they rang the doorbell of the President's House in the small hours of morning. He persuaded Alfred P. Sloan, Jr., '95, to buy for M.I.T. Lever Brothers' vacated headquarters at 50 Memorial Drive. He won the approval of Archbishop Richard Cushing for Catholic use of the nondenominational chapel to be built on the West Campus. And it all seemed to come with ease and grace.

Just six days after he was inaugurated, Killian found his administration challenged sharply and unexpectedly—"a hurricane of controversy"—when the House of Representatives Committee on Un-American Activities named a member of the faculty a "teacher of red revolution." Killian responded with a widely-admired statement on freedom of inquiry.

There were mistakes, of course, such as Killian's premature announcement in 1956 in New York that M.I.T. would start a School for Advanced Study. Perhaps it was a good idea, says Killian, but it was launched without the commitment of either faculty or administration, and the president was left "dangling in the breeze."

But beside Killian's achievements for M.I.T. and the nation—they include a series of Atoms for Peace Awards, the idea of public television, a distinguished tenure as White House science advisor, and influential memberships on countless commissions and boards—such errors and frustrations loom small.

The late Thomas K. Sherwood, Sc.D.'29, whom Killian had made dean of engineering in 1946, said it for all of us when he wrote to Killian upon retiring: "More than any other, you are responsible for making M.I.T. great."—*John Mattill* □


What better time for M.I.T. insignia
■ Glass Beer Mug with platinum M.I.T. insignia seal. $6
■ Solid Brass Paperweight with M.I.T. Seal engraved. $15
■ Ceramic Piggy Bank. Creamy white with gold trim ears and hooves. Scarlet seal. $12.95
■ Ceramic Coffee Cup with tri-color insignia seal. $5.95
the Coop
HARVARD COOPERATIVE SOCIETY
▲ Hooded Insignia Sweatshirt. Scarlet seal on grey or white seal on scarlet. S–XL in a cotton/poly fleece. $20
▲ T-Shirt with scarlet M.I.T. letters and seal. Contrasting band on neck and sleeve. Cotton/poly blend. S–XL. White only. $8
■ Not Shown: T-Shirt with new M.I.T. logo on left chest. 100% cotton. S–XL. Maroon only. $8
White with M.I.T. block letters, front only. Crewneck with insignia seal on front. Grey, maroon or white. $16
Available at M.I.T. Student Center. Coop Charge, Mastercard, Visa and American Express welcome.
Call toll free: 1-800-792-5170 within Mass., 1-800-343-5570 outside Mass. Tech Coop open Mon.–Sat. 9:15 to 5:30pm.

NEWS FROM THE DEPARTMENTS

Seeking to give undergraduates "a tactile knowledge of steel beyond measurements in the laboratory," Professor Samuel Allen, Ph.D.'75 (left), in the Department of Materials Science and Engineering, has turned to blacksmithing. Once students start working with steel, says Allen's assistant Forrest Whitcher (striped shirt), "they begin to think of steel as a plastic medium instead of an inert one." Another advantage, says Allen: "We have time for standing around and shooting the breeze while waiting for things to heat. It gives students a chance to hear what a professional does and thinks about." Students in the picture, helping make a fireplace fork, are Jonathan Suber, '87, and Charles Lane, '85 (right). (Photo: Calvin Campbell)

I CIVIL ENGINEERING

Shih-Ying Lee, S.M.'48, and **Lucien A. Schmit, Jr.,** '48, were honored early last spring by election to the National Academy of Engineering. Lee, who is executive vice-president of Setra Systems, Inc., Acton, Mass., was cited for "original research on control valve stability, for innovative dynamic measurement instrumentation, and for several entrepreneurial commercializations of his inventions." The citation to Professor Schmit, a member of the engineering faculty at the University of California, Los Angeles, was "for pioneering work in structural synthesis, combining finite element analysis and nonlinear programming algorithms to create a power class of modern structural design methods."

Professor **Robert V. Whitman,** Sc.D.'49, is the first non-Californian elected president of the 36-year-old Earthquake Engineering Research Institute, a professional society dedicated to reducing earthquake hazards. Whitman, a member of the M.I.T. faculty since 1953, has worked in earthquake engineering since the mid-1960s—studies of the dynamic properties of soils, soil-structure interaction, and structures' responses to earthquake motions.

Kenneth R. Hoffman, S.M.'77, has joined Barkan Construction Co., Inc., Chestnut Hill, Mass., as chief estimator and project manager. Hoffman is responsible for Barkan's construction cost estimating and project planning. . . . **Rodney P. Plourde,** Ph.D.'71, has been elected to the board of directors of Fay, Spofford and Thorndike, a Lexington, Mass. engineering firm. Plourde, a company vice-president, is also manager of the firm's transportation planning, Environmental Assessment Department, and Airport Division. . . . **Mumtaz J. Shabbir,** S.M.'80, writes, "Working as a senior engineer on the seismic analysis and design of a major earth and rock fill dam and hydroelectric project—the Kalabagh Dam Project—in Pakistan."

Duncan W. Wood, S.M.'76, has been appointed vice-president of the Water Quality Group in Anderson-Nichols' Environmental Division, Clinton, Mass.; he's responsible for all wastewater, solid waste and water resources projects. Previously he served as vice-president of the Water Resources Group. . . . **Jerome B. York,** S.M.'61, has been elected vice-president of advanced manufacturing operations at the Chrysler Corp., Detroit, Mich., responsible for advanced manufacturing planning, current manufacturing planning, and manufacturing engineering activities. . . . **Maurice Freedman, Jr.,** '54, a principal of Sasaki Associates, Inc., Watertown, Mass., a planning and design firm, has been named to the Massachusetts Designers Selection Board by Governor Michael S. Dukakis. . . . **Jon Hagstrom,** S.M.'65, vice-president and director of research of CBI Industries, Plainfield, Ill.—an authority on shell buckling and dynamic analysis of structures—has been elected a fellow of the American Society of Mechanical Engineers.

II MECHANICAL ENGINEERING

Professor **Triantaphylios R. Akylas,** Ph.D.'81, has been honored with the M.I.T.'s Henry L. Doherty Professorship in Ocean Utilization for 1985. Akylas, whose doctorate is in applied mathematics, will study details of the processes of shore erosion by ocean waves.

William H. Heiser, Ph.D.'62, joined Aerojet General, Sacramento, Calif., as vice-president and director to organize and manage the Aeroject General Propulsion Research Institute. In this position, Heiser will create an organization of scientists and engineers to study advanced rocket propulsion systems and will help expand the firms' relationships with universities and the nation's scientific community. Just before taking his new post, Heiser was made a fellow of the American Institute of Aeronautics and Astronautics for his work in the field of aircraft propulsion. . . . **Lawrence D. Blackman,** S.M.'81, writes, "Findings from 1983 and 1984 control system optimization studies at Rockwell International (Downey, Calif.), have been published. . . . A Transient Response Analysis Program (TRAP), written under contract to NASA (Houston), has been published in their *Tech Briefs*. . . . Advanced robotics and automation research to support the NASA Space Station Project is being conducted at Rockwell." . . . **John E. Mayer, Jr.,** Sc.D.'60, is currently director of Advanced Engineering at Kennametal, Inc., Latrobe, Penn.

The General Electric Co., Lynn, Mass., has honored two alumni: **R. Sheldon Carpenter,** S.M.'80, received the Aircraft Engine Business Group's Ed Woll Young Engineer Award—recognizing his innovations on GE's F404 engine; and **Fredric Ehrich,** Sc.D.'47, staff engineer, received the Aircraft Engine Business Group's Technical and Professional Societies Award recognizing his continuing contributions to the advancement of engineering education, literature, and technical societies. . . . **Richard T. Roca,** Sc.D.'72, manager of planning and engineering of all new switching-based AT&T services and products at Bell Laboratories, Holmdel, N.J., has been elected to fellow of the American Society of Mechanical Engineers.

III MATERIALS SCIENCE AND ENGINEERING

The M.I.T. School of Engineering's Materials Processing Center is now under the direction of Professor **Ronald M. Latanision,** a specialist in corrosion science who directs the department's H. H. Uhlig Corrosion Laboratory. Stressing research

on the internal structures of materials from the macroscopic to the atomic level, the center has an annual research volume of over $4 million, roughly 50 percent of which is under industrial sponsorship. Latanision, at M.I.T. since 1975 following metallurgy studies at Penn State and Ohio State, succeeds Professor **H. Kent Bowen,** Ph.D.'71, who's now giving full attention to developing a new interdisciplinary program in manufacturing systems. Meanwhile, Professor Bowen has been appointed by Lee Iacocca, chairman of Chrysler Corp., to be a member of Chrysler's new Technology Advisory Council. And Latanision was honored by election to the National Academy of Engineering, cited for research on environmental effects on the chemical and mechanical properties of engineered materials.

Rodney E. Hanneman, Ph.D.'61, vice-president of research, development and energy resources at Reynolds Metals Co., Richmond, Va., has been appointed vice-president, corporate quality assurance and technology. In his new role, Hanneman will be the company's chief technical officer with responsibility for corporate research and development, engineering and quality assurance.

Kyocera Corp. of Kyota, Japan, the world's largest maker of ceramic packaging for integrated electronic circuits, is the donor of $1 million to endow a professorship in ceramics science and engineering at M.I.T., and **W. David Kingery,** '48, has been named the first Kyocera Professor. A member of the faculty since 1951, Kingery is known for research on a variety of ceramic materials and processes, and he is the author of a widely influential textbook.

Maurice E. ("Bud") Shank, Sc.D.'49, director of engineering at Pratt and Whitney Group, United Technology Corp., was made a fellow of the American Institute of Aeronautics and Astronautics last spring; he was cited for his role in the development of advanced fuel-efficient commercial gas turbines.

V CHEMISTRY

Another honor for Professor **Mark S. Wrighton** of M.I.T.: the Fresinius Award Phi Lamdba Upsilon, the chemistry honor society, for his contributions as a young faculty member through both teaching and research. . . . Professor **Dagmar Ringe,** a lecturer in the department at M.I.T. and director of the Chemistry Undergraduate Laboratory, is the recipient of the first Margaret Oakley Dayhoff Award given by the Biophysical Society. This annual award is presented to recognize a junior woman scientist of very high promise who has not yet reached a position of high recognition with the academic community. Ringe was recognized for her work on protein x-ray crystallography, done in collaboration with the research group of Professor **Gregory Petsko.**

Daniel D. Traficante, Ph.D.'62, has joined Monsanto (St. Louis, Mo.) and been appointed a fellow in Monsanto Co.'s program which recognizes those individuals who make significant continuing technical contributons to their specific disciplines. Traficante will direct the Life Sciences Nuclear Magnetic Resonance (NMR) Consortium, where he will develop new NMR applications and user education, and will balance the NMR needs of five research organizations. . . . **Homer Fay,** Ph.D.'53, reports, "I'm still in Buffalo, N.Y. with the Linde Division of Union Carbide. Enjoying sailing on Lake Erie. Son Frank is also a M.I.T. graduate in naval architecture." . . . **Jose M. Torradas,** Ph.D.'82, has joined the Polymer Products Department at the DuPont Co., Wilmington, Del. as a research engineer.

Henry N. Sachs, S.M.'25, an account executive at the insurance firm of Kalvin-Miller International, New York City, passed away on February 4, 1980. During his five and a half years of service in the U.S. Army, Sachs rose to the rank of colonel and received the Legion of Merit for gallantry in action and a Silver Star.

VI ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Six alumni and faculty of the department at M.I.T. were elected to the National Academy of Engineering early this year:

☐ **James P. Gordon,** '49, technical staff consultant to the Electronics Research Laboratory at AT&T Bell Laboratories, Holmdel, N.J., "for fundamental contributions to quantum electronics, including demonstration of the first maser and of the information theory of optical communication channels."

☐ **Erich P. Ippen,** '62, professor of electrical engineering at M.I.T., "for pioneering contributions to nonlinear optics in optical waveguides and ultrashort-optical-pulse-generation techniques."

☐ **Robert Price,** Sc.D.'53, chief scientist, M/A-Com Linkabit, Inc., Lexington, Mass., for "pioneering achievements in applying statistical communication theory to radio communication, radar astronomy, and magnetic recording."

☐ **Robert C. Sprague,** '23, founder, director, and honorary chairman of Sprague Electric Co., North Adams, Mass., "for inventing electronic components and for entrepreneurship in founding a major electronics company which he directed for 58 years as president and chairman."

☐ **George L. Turin,** '51, dean of engineering and applied science at the University of California, Los Angeles, "for outstanding contributions to communication theory and practice and for leadership in engineering education."

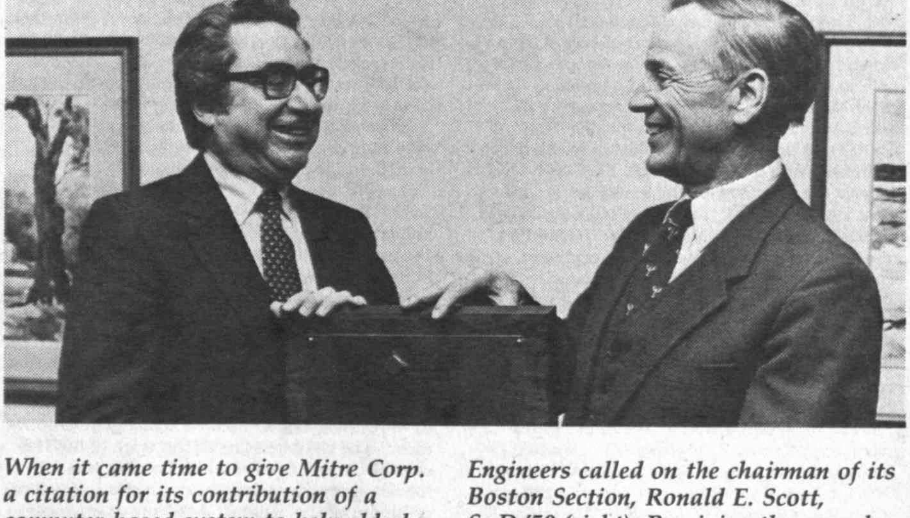
☐ **Willis H. Ware,** S.M.'42, corporate research staff, Rand Corp., Santa Monica, Calif., "for pioneering contributions to computer technology, from development of machines and systems to operations and engineering for national security and civil capability."

Andrew Lippman, '71, director of the Architecture Machine Group in the new M.I.T. Arts and Media Center, now holds the NEC Career Development Professorship of Computers and Communications. Lippman was research associate in architecture before joining the faculty in computer graphics in 1980. The professorship is funded by a grant from NEC Corp. of Tokyo, Japan and is designed to promote technological and cultural change between the U.S. and Japan.

Professor **Richard B. Adler,** '43, associate head of the department at M.I.T., has been honored by appointment to a new chair, the Distinguished Professorship of Electrical Engineering and Computer Science. After initial gifts of $300,000, the professorship will be funded by annual giving of at least $100,000 from its anonymous sponsors; gifts in excess of that amount will be applied toward eventual endowment of the chair. As associate head since 1978, Adler has taken major responsibility for development of the new Microsystems Technology Laboratories now being completed, and for a program of microsystems education and research that will utilize the new facilities.

James L. Flanagan, Sc.D.'55, director of AT&T Bell Laboratories' Acoustical and Behavioral Research Center, is cowinner of the 1985 L. M. Ericsson Prize for notable contributions to telecommunications. Flanagan and Professor Gunnar Fant of the Royal Technical University, Stockholm, who shared the award, were cited for "outstanding work on speech analysis and speech transmission." Awarded only every third year, the 1985 prize was given in Stockholm by the King of Sweden on May 6. Flanagan has worked in the field of speech perception, processing, and transmission at Bell Labs since 1957. Fant, a native of Sweden, was a research associate in acoustics at M.I.T. in 1950-51, and since then he has collaborated with Professor Morris Halle and the late Professor Roman Jakobson in work on the acoustics of speech production.

William D. Couper, S.M.'77, is currently senior scientist of new product development at the Merrimack Component Division of M/A-Com Omni Spectra, Inc., Nashua, N.H.; responsible for all phases of microwave connector research and development. . . . **Randal E. Bryant,** Ph.D.'81, writes, "I recently joined the Computer Science faculty at Carnegie-Mellon University as an assistant professor, after spending three years in a similar position at Caltech. I married Janice Rukens in May 1983, and we had a son, Jacob, in May 1984." . . . **Einar Greve,** S.M.'53, has been promoted from executive vice-president to president and CEO at Tuscon (Ariz.) Electric Power Co. . . . **Juan Carlos Mercier,** S.M.'84, has joined Hewlett-Packard in Cupertino, Calif., and is planning to attend Stanford University in the fall to obtain his M.B.A. . . **Aldolfo Guzman,** Ph.D.'69, writes, "Effective June 1, I am associated with the Electrical Engineering Department of the Center for Research and Advanced Studies, a collection of research departments belonging to the National Polytechnic Institute, a large federal university in Mexico City. My professional interests continue to be image processing, pattern recognition and artificial intelligence, parallel computing and distributed processing, and geographic data bases." Professor Guzman heads the Computer Science



When it came time to give Mitre Corp. a citation for its contribution of a computer-based system to help elderly patients identify local eye doctors, the Institute of Electrical and Electronics Engineers called on the chairman of its Boston Section, Ronald E. Scott, Sc.D.'50 (right). Receiving the award for Mitre: Charles A. Zraket, S.M.'53, executive vice-president.

section of his department, which recently launched Ph.D. and M.Sc. programs.

Captain **James L. Walker,** U.S.C.G., E.E.'67, is commander of all United States Coast Guard functions in Europe, primarily navigation and marine safety, with headquarters in London. . . . **Rudolph A. Schlais, Jr.,** S.M.'65, was promoted (November 1, 1984) to director of engineering for the newly formed Fisher Guide Division of General Motors Corp., Warren, Mich.

Eliezer Gafni, Ph.D.'82, assistant professor in the Department of Computer Science at the University of California, Los Angeles, was selected to receive a 1985 Presidential Young Investigator Award. Gafni is presently researching computer networks, seeking a unifying framework for investigations conducted in electrical engineering and computer science. . . . **Leonard M. Magid,** Ph.D.'62, a solar energy consultant at PA Technology, Hightstown, N.J., has been promoted to a principal in this firm. Joining PA in 1974, Magid was responsible for creating the U.S. National Photovoltaic Solar Energy Conversion Program within the National Science Foundation, and he stayed with the program when it moved ultimately to the U.S. Department of Energy.

VI-A INTERNSHIP PROGRAM

On April 19 VI-A completed selection of its 68th class. Ninety-four new students will be distributed among our 22 companies. This means that 25.5 percent of the current sophomore class in Course VI will be in VI-A. The department's imposed quota on the companies limited others of the 216 who applied from being accepted into the program.

Bell Communications Research (Bellcore) accepted its first two students this year, joining longtime participant AT&T Bell Laboratories. **Irwin Dorros,** '56, vice-president, and **Chester M. Day, Jr.,** '57 (a VI-A alumnus), district research manager, Exchange Network Research Division, were both instrumental in completing the arrangements for Bellcore's VI-A participation. Professor **Frederic R. Morgenthaler,** '55 (also a VI-A alumnus), will serve Bellcore as well as continuing as VI-A advisor at AT&T Bell Labs. Incidentally, Professor Morgenthaler has recently returned from the Far East where he gave a number of invited lectures during two weeks in mainland China and then continued on to Tokyo for two more weeks of M.I.T. business and pleasure.

On February 21, Digital Equipment Corp. was represented at a reception in our Grier Conference Room by a number of VI-A's: **William R. Biderman,** '78, **Jeffrey M. Blacksin,** '83, **David E. Buffo,** '81, **Ramin Khorram,** '83, **James E. Mandry,** '81, and **Donald E. Nelson,** '61.

Paul E. Braisted, '79, informs us he is now with Trumball Navigation, Mountain View, Calif. . . . **Alan M. Marcum,** '78, sent us a card from Hong Kong, while he was on his way to Singapore to teach an advanced Unix seminar. . . . **Michael Moncavage,** '82, with Schlumberger in Saudi Arabia, writes (while on a week's tour of China) that he will return to Boston in the fall to attend Harvard University.

Since our previous article, a number of visitors have found their way to the VI-A Office: **Donald L. Brinkley,** '79, from Vienna, Va., where he is a research scientist with System Development Corp.; **Leonard N. Evenchik,** '77, who now has his own firm, Evenchik & Associates, Cambridge; **Charles A. Freeman,** '80, with Hewlett-Packard Laboratories, Palo Alto, who was spending some time in Intervale, N.H.; **Steven D. Krueger,** '79, from Texas Instruments in Dallas, who came by to talk over the assignments of several VI-A students in his group at T.I.'s Computer Science Laboratory; **Robert B. Matson,** '73, president of Financial Management, Boston, who talked with Director Tucker about his new firm and the work in which it's involved; **Eduardo H. Moncada,** '78, a process engineer with A.M.D., Austin, Tex.; **Anthony J. Riccobono,** '84, a member of the technical staff at Hughes Space & Communications Division, El Segundo, Calif.; and **Steven Swerling,** '63, who was on campus recruiting for Mentor Graphics Corp., Beaverton, Ore., where he is a founder and vice-president, engineering.

A reminder for anyone who may be interested that applications are now being received for the new position of associate director of the VI-A Internship Program. Resumes may be sent to Director Tucker.—John A. Tucker, Director, VI-A Internship Program, M.I.T., Room 38-473, Cambridge, MA 02139

VIII PHYSICS

Major new honors came early this year to two distinguished professors emeriti of the department at M.I.T.: Professor **Bruno Rossi** received the National Medal of Science in White House ceremonies on February 27; and one day later Professor **Philip M. Morse** was elected to the National Academy of Engineering. Rossi, 79, who joined the faculty in 1946, was cited for "fundamental contributions to physics and astronomy through his research into the nature and origin of cosmic rays"; and Morse was named "for pioneering and seminal contributions to the science and practice of operations research."

After nearly a decade as coordinator for M.I.T.'s role in the McGraw-Hill Observatory at Kitt Park, Ariz., **Jeffrey E. McClintock,** Ph.D.'69. has been named associate director for M.I.T. of the observatory. He will share its management with representatives of the observatory's two other owners, the University of Michigan and Dartmouth. A member of the M.I.T. staff since completing his doctorate, McClintock is now principal research scientist in physics, specializing in neutron-star binary systems.

No ordinary physicist could write it, but **Richard P. Feynman,** '39, professor of physics at Caltech, fits no mold—which goes a long way to explain his new book, in association with Ralph Leighton: *Surely You're Joking, Mr. Feynman!* (Norton, 1985, $16.95). In a prepublication review, *Booklist* described it as "delightfully stream-of-consciousness stories . . . ripe with detail and nonsequiturs yet always (having) a point. . . . A vivid portrait of a lively, brilliant thinker who is intellectually and personally adventurous."

X CHEMICAL ENGINEERING

Two prominent alumni of the department were honored by election to the National Academy of Engineering early this year: **Paul M. Cook,** '47, chairman and chief executive officer of Raychem Corp., Menlo Park, Calif., "for his pioneering research into the application of radiation chemistry to polymers and the development of innovative technologies in engineered materials"; and **Ronald E. Rosensweig,** Sc.D.'56, senior research associate at Exxon Research and Engineering Co., Annadale, N.J., "for discoveries and endeavors spawning high-technology applications of magnetic fluids and ferrohydrodynamics."

A major new honor for **Ralph Landau,** Sc.D.'41, whose name adorns the department's building completed in 1976: the National Medal of Technology, presented in February by President Ronald Reagan at the White House. "Under Ralph Landau's leadership," said the citation, "his company became the major world source of new petrochemical processes, contributing to about one-fourth of all new processes commercialized in the past 25 years. Licensing of these technologies and design of plants to produce them have resulted in more than 400 plants in 40 countries." The citation refers to the work of the Halcon SD Group, Inc., of which Landau was founding president and chairman. He's now vice-president of the National Academy of Engineering, adjunct professor at the University of Pennsylvania, consulting professor at Stanford, and president of Listowel, Inc., New York.

XIII OCEAN ENGINEERING

Dick Kosiba, N.E.'53, assumed a position as vice-president for quality and techology at McDermott, Inc., and continues living in Wintergreen, Va. . . . **Shashank V. Karve,** O.E.'81, is an associate in the Marine Division at Brian Watt Associates, Inc., specializing in floating production systems for deepwater, marginal, and remote oil fields. . . . **Yehuda Dror,** S.M.'81, writes that as of January 1, 1985, he became engineering manager at Veritas Technical Services, Houston. . . . **John H. Sweeney,** S.M.'60, reports, "I am an engineer and naval architect for Henry T. Hinckley Co., Southwest Harbor, Me., currently working on a new 51-foot auxiliary sailing yacht." . . . **Donald P. Courtsal,** S.M.'56, retired on March 31, 1985, as senior vice-president of manufacturing at the Dravo Corp., Pittsburgh, Penn.

Raphael Vermeir, S.M.'79, has transferred to Conoco's London office in the U.K. Acquisitions Group. . . . Captain **Robert W. Curtis,** U.S.N., S.M.'42, of Arlington, Va., passed away on November 27, 1984; no further details are available.

XIV ECONOMICS

David Garvin, Ph.D.'79, has been named an associate professor of economics at the Harvard Business School. Garvin's speciality is in quality management and the management of operations, currently interested in manufacturing strategy and proposals to revive America's faltering productivity and quality. He twice won the McKinsey Award for the best article in the *Harvard Business Review* in 1982 and 1983. . . . **Michael R. Dohan,** Ph.D.'69, reports his current professional affiliations: director of the Social Science Laboratory for Research and Teaching as well as associate professor of economics at Queens College (N.Y.); senior consultant for the financial planning firm of Family Financial Consultants, Inc., Huntington, N.Y. . . . **Richard C. Marston,** Ph.D.'72, has co-edited *Exchange Rate Theory and Practice*, published by the University of Chicago Press, January 1985.

XV MANAGEMENT

David R. Zibbell, S.M.'63, is the new vice-president of finance, administration, and operations of Delval Manufacturing Co., Willow Grove, Penn. He also received certification as a CPA in October 1983. . . . **Bruce McFadden,** S.M.'75, writes from Belgium, "Still finding working in Europe an enjoyable challenge. Doing and learning a lot. The family enjoys it too." . . . **Paul Schaller,** S.M.'78, reports, "I am director of industry marketing for Vitalink Communications—data communications over satellite networks in Menlo Park, Calif. My wife Mary is director of marketing at Telebit Corp., specializing in high speed dial-up modems, and we have two children—Kristin (age 4) and Michael (Age 3)."

Michael Jimenez, S.M.'77, is head of Exxon Engineering's Economic Forecasting Group for capital construction projects worldwide, Florham Park, N.J. . . . **Robert Jarrow,** Ph.D.'79, associate professor of finance and economics at Cornell, has been awarded tenure in the University's Samuel Johnson Graduate School of Management. . . . **Frederic G. Westendorf,** S.M.'64, is a program manager—business planning for large systems, Europe, at the IBM Corp., White Plains, N.Y.

Gregory F. Zaic, S.M.'72, has joined Vista Ventures, a venture capital firm in New Canaan, Conn. . . . **Robert B. Hedges, Jr.,** S.M.'84, writes, "Most happily employed at Management Analysis Center, Inc,, Cambridge. Other Sloan colleages include: **Will Rodgers,** S.M.'68; **Pierre Loewe,** S.M.'70; and **Chris Nelson,** S.M.'80. My work focuses on corporate strategy for financial institu-

tions. In October 1984, I had the good fortune to present an original research paper on the determinants of bank merger and acquisition premiums at the fourth annual Strategic Management Society Conference in Philadelphia. I ran into Sloan professors **Mel Horwitch** and **John Morecraft** at the conference." . . . **Joseph Combs,** S.M.'77, has been promoted to product manager—programming software at Xerox Computer Services, Los Angeles.

Alexis Falquier, S.M.'67, writes, "Now directing McKinskey's operations in Mexico. . . . We are looking into the fundamentals of establishing world-class competitiveness in a number of Mexico's industrial sectors. It's a most satisfying challenge, being carried out by a top-notch professional staff of 20-plus, including two former M.I.T. graduates." . . . **Thomas M. St Clair,** S.M.'58, has been promoted to vice-president, treasurer, and chief financial officer at Koppers Co., Inc., Pittsburgh, Penn. . . . **Ronald J. Zlatoper,** S.M.'75, is currently a captain in the U.S. Navy and serving as the military assistant to the secretary of defense, Caspar Weinberger, in Washington, D.C.

William M. Ryan, S.M.'64, has been named vice-president of marketing for Aeonic Systems, Inc., Billerica, Mass., responsible for all sales and marketing activities, including advertising and supervision of the sales force. . . . **John H. Erdman, Jr.,** S.M.'75, has been named a managing director of Morgan Stanley, Inc., New York City. Erdman joined the firm in 1975 as an associate, becoming a vice-president in 1980 and a principal in 1982. . . . **James Forese,** S.M.'59, vice-president and controller at IBM, Armonk, N.Y., has been elected to the board of trustees at Rensselaer Polytechnic Institute, Troy, N.Y.

Kong-Heong Tan, S.M.'71, writes, "Have been working in Taiwan since June 1976 and like the regional travel side-benefit. Unfortunately, there aren't that many Sloan master's program graduates around to make life that much more interesting. **Robert Mao,** S.M.'72, of IT&T, Taiwan, is one that I see now . . . that we have become neighbors . . . at our seaside hideaways near Tapei. Contact me if any Sloan alumni needs assistance while doing business in Taiwan." . . . **Jay Petschek,** S.M.'82, writes, "I recently joined the investment banking firm of Landenburg, Thalmann and Co., New York City. My new responsibilities revolve around investment management, venture capital, and corporate finance. If anyone wishes to have lunch, I am still located midtown."

Stanley Zalkind, S.M.'64, resigned last October as president and CEO of Electro Audio Dynamics, Inc., Great Neck, N.Y. . . . **Henry Barg,** S.M.'73, director of corporate relations at Boston University, has been promoted to director of development, responsible for the development activities of many of the university's schools and colleges as part a five-year, $200 million campaign.

Fourteen essays based on the Sloan School's three-year study of industrial relations in transition have been published under the title of *Challenges and Choices Facing American Labor* (M.I.T. Press, 1985). Professor **Thomas A. Kochan** was editor for the project, and contributions include Professors **Harry C. Katz** and **Robert B. McKersie** of the Sloan School, **E. David Wangner,** Sloan School lecturer; and Professors **Henry S. Farber** and **Michael J. Piore** of the Department of Economics.

SLOAN FELLOWS

Two Sloan Fellows are among new members of the National Academy of Engineering chosen early this year: **Philip M. Condit,** S.M.'75, vice-president for marketing and sales of Boeing Commercial Airplane Co., Seattle, cited "for important personal contributions and exceptional technical leadership in the design and advancement of commerical jet transport aircraft"; and **Howard H. Kehrl,** S.M.'60, vice-chairman of the board of General Motors Corp., for "outstanding contributions to the advancement of automotive science and engineering." Condit was also made a fellow of the American Institute of Aeronautics and Astronautics early last spring, cited for his contributions to the development and production of the Boeing 757 transport.

Kenneth F. Holtby, S.M.'62, senior vice-president of the Boeing Co., Seattle, Wash., has been named a member of the Technology Advisory Council of the Chrysler Corp. . . . Two promotions have been made within the U.S. Postal Service, Washington, D.C.: **Jerry K. Lee, Sr.,** S.M.'82, from assistant postmaster general, Department of the Controller, to senior assistant postmaster general for the Postal Service's Research and Management Systems Group; and **William R. Cummings,** S.M.'80, from assistant postmaster general for planning to senior assistant postmaster general, Finance Group, and chief financial officer. . . . **James E. Landers,** S.M.'67, vice-president of human resources at Conoco, Du Pont's wholly-owned energy subsidiary, Wilmington, Del., has been promoted to vice-president of employee relations for Du Pont; he will retain responsibility for Conoco human resources.

MANAGEMENT OF TECHNOLOGY PROGRAM

Charles A. Berry, S.M.'83, has published a paper with Professor **Edward Roberts** in November on "Entering New Businesses: Selecting Strategies for Success." Charles has been traveling to the West Coast frequently this year, working on an aquisition of a small California company—Advanced Kinetics—for Pilkington (U.K.) and met up with **Julian Nikolchev,** S.M.'83, and **John Harrison,** S.M.'83, in February in San Francisco. Julian continues with SRI International there, and John was in San Francisco on a special six-week assignment for his company, Parsons Brinckerhoff Quade and Douglas. Julian called Jane Morse in February to tell her about the "reunion" and to report he and Betsy had a vacation trip planned in Europe at the end of March. Their little girl, Alexandria, is now two, and Julian says she's very talkative.

Exciting news has come in from Glasgow from **Charles Bow,** S.M.'84: he became engaged in April and wedding plans are set for July. His fiancee, Alison Smith, is an ophthamologist working about 80 miles from Charles. At the time of this writing she was beginning to search for a new position in the Glasgow area. Though Charles explained over the phone his head was in the clouds and he hadn't been able to think about work much lately, he did admit there were changes going on at Barr & Stroud and its division at Pilkington, with the potential for several exciting new possibilities for him.

Jane Morse met **Kenneth W. Miller,** S.M.'82, in Orlando, Fla., on March 1 at the Sloan Fellows convocation there. (Management of Technology Program graduates and all Sloan School alumni/ae were invited to attend. It was an excellent day of activity run by Professors **Edward Roberts** and **Thomas Allen** on the topic of the Management of Technology.) Ken is now in Tarrytown, N.Y., having been recently promoted at Duracell. He still has a commuter marriage until May, however, as Joan won't finish her Executive M.B.A. program until then. By this summer, they hope to be settled in the Connecticut area.—Jane Morse, Program Manager, M.I.T., Room E52-125, M.I.T., Cambridge, MA 02139

XVI AERONAUTICS AND ASTRONAUTICS

Membership in the National Academy of Engineering was voted three alumni and members of the department early this year:

□ **Donald C. Fraser,** '62, vice-president—technical operations, Charles Stark Draper Laboratory, Inc., "for unique engineering contributions that brought digital control technology to practice and are leading to fault-tolerance systems in the future."

□ **Shan-Fu Shen,** Sc.D.'49, John Edson Sweet Professor of Engineering at Cornell University, "for fundamental contributions to aerodynamics and non-Newtonian fluid mechanics."

□ **Sheila E. Widnall,** '60, professor in the department at M.I.T., "for fundamental contributions to the fluid mechanics of rotary and fixed-wing aircraft, and for outstanding service to engineering education and to the profession of engineering."

Five alumni of the department were named fellows of the American Institute of Aeronautics and Astronautics during AIAA's annual meeting last spring:

□ **Arthur Gelb,** Sc.D.'61, president of Analytical Sciences Corp., Reading, Mass., "for contributions to the application of modern control and estimation theory to integrated navigation and guidance systems . . ."

□ **Mark E. Kirchner,** '48, director of engineering at Boeing Commercial Airplane Co., for "original contributions to higher standards of stafety, excellent handling qualities, and accuracy in performance prediction in commercial transports."

□ **William C. Schneider,** '49, vice-president of Computer Sciences Corp., Falls Church, Va., "for dynamic leadership of space technology and development for over two decades . . ."

□ **Jason L. Speyer,** '60, Harry H. Power Professor of Engineering at the University of Texas, Austin, "for contributions to deterministic and stochastic optimal control theory and applications to aerospace problems."

□ **Shiela E. Widnall,** '60, for "unique and fundamental contributions to fluid mechanics of aircraft . . ."

John E. Draim, S.M.'69, writes, "I recently was promoted to principal aerospace engineer at Anser, Inc., Arlington, Va. Have published an AIAA paper describing probably the first four-satellite constellation yielding continuous, global coverage. Previously, it had been thought that continuous global coverage required five satellites."

Edwin N. Myers, S.M.'61, is a consultant for the Institute for Defense Analysis; a member of the U.S. delegation to CoCom (Paris); and a member of the Department of Commerce Technical Advisory Committees on Instrumentation and Semiconductors. . . . **Charles L. Wilson,** S.M.'63, writes, "For the last three years I have been operating out of Lausanne, Switzerland, as director of European operations for Weidlinger Associates, consulting engineers of New York City. Have just opened a Weidlinger office in Brussels, Belgium."

Kenneth R. Britting, Sc.D.'71, a mechanical engineer at the Northrup Corp., Norwood, Mass., passed away unexpectedly on February 18, 1985. Britting specialized in navigation equipment and had worked in R&D at Northrup since 1977. He was author of the college textbook, *Inertial Navigation Systems Analysis,* and a member of several professional societies.

TECHNOLOGY AND POLICY PROGRAM

Jonathan Weiss, S.M.'78, has accepted a new position as a systems analyst with TEM Associates, Washington, D.C. . . . **Leslie Klein,** S.M.'83, has recently become a member of the technical staff of the Digital Terminal Systems, Bell Laboratories, Holmdale, N.J.

Tapio Kuusinen, S.M.'79, has joined the Regulatory Reform Staff of the EPA Policy Office in Washington, D.C., where he is working on recycling incentives for the agency's hazardous waste effort. . . . **Richard Thomas,** S.M.'79, has co-founded a new consulting company—Epsilon International—which will focus on engineering, planning, and policy problems, primarily in southern Europe, the mid-East, and southern Asia.—Richard de Neufville, Chairman, Technology and Policy Program, M.I.T., Room 1-138, Cambridge, MA 02139

R. L. Bisplinghoff

W. W. Buechner

G. E. Nealand

J. G. Trump

Raymond L. Bisplinghoff, 1917-1985

Raymond L. Bisplinghoff, who was a member of the M.I.T. faculty from 1946 until 1970 and for much of his career an important figure in U.S. science and technology policy, died on March 5; he was 68.

Bisplinghoff joined the Department of Aeronautics and Astronautics four years after receiving his master's degree from the University of Cincinnati and promptly took charge of research and teaching in flight vehicle structures. Later he served as director of the Aeroelastic and Structures Research Laboratory and chairman of the department's Aerospace Research Division.

Returning from a four-year leave of absence to serve as NASA's associate administrator, Bisplinghoff was made head of the Department of Aeronautics and Astronautics in 1966, and two years later was appointed dean of the School of Engineering. In 1970, Bisplinghoff became deputy director of the National Science Foundation and in 1974 chancellor of the University of Missouri at Rolla.

Bisplinghoff was president of the American Institute of Aeronautics and Astronautics in 1966, and he held AIAA's 1958 Sylvanus Reed Award for developing ways to calculate aircraft loads and stresses during maneuvers. He held honorary degrees from his alma mater and Case Institute of Technology.

William W. Buechner, 1915-1985

William W. Buechner, '35, professor emeritus of physics who was chairman of the department from 1961 to 1967, died on March 12 in Cambridge, after a brief illness. He was 70.

Professor Buechner came to the Institute as an undergraduate from Vallejo, Calif., in 1931, and he spent his entire career at M.I.T. As a graduate student (Ph.D. 1939) he became director of the Van De Graaff electrostatic generator that was moved to the campus from the Round Hill, Mass., estate of Colonel E. H. R. Green. Later—as a member of the faculty—he collaborated with the late Professor Robert J. Van de Graaff in building other high-voltage generators, including the so-called "ONR Generator" in Building 58.

Well known in the international physics community, Professor Buechner held visiting professorships at the National University of Mexico (where he was awarded an honorary doctorate and the title of professor extraodinario), Catholic University in Rio de Janeiro, and a number of institutions in India. He held the Charles B. Dudley gold medal of the American Society for Testing Materials, and in 1946 he received the Naval Ordnance Development Award for war-time contributions as director of the M.I.T. High-Voltage Laboratory.

G. Edward Nealand, 1912-1985

G. Edward Nealand, '32, retired director of purchasing, died on March 19 following an accident in his home in Sarasota; Fla. He was 73.

Regarded as one of the deans of college purchasing, Nealand was the architect of M.I.T.'s first central purchasing system shortly after becoming director of purchasing in 1955. In 1961, he went to Afghanistan, where he was responsible for writing the specifications for equipping the science buildings for the newly-established University of Kabul.

Nealand had held major posts in the National Association of Educational Buyers before retiring from M.I.T. in 1975, and at that time he was made an honorary life member of NAEB.

Active in alumni affairs, Nealand was awarded the Lobdell Distinguished Service Award of the Alumni Association. He had been in charge of arrangements for his class' 40th, 45th, and 50th reunions and at the time of his death was vice-president of the M.I.T. Club of Cape Cod.

John G. Trump, 1908-1985: Pioneer in High Voltages

John G. Trump, Sc.D.'33, a pioneer in the generation and use of high-voltage energy who was a member of the M.I.T. faculty from 1936 until retirement in 1980, died at his home in Winchester, Mass., on February 21; he was 77.

Trump was founder and long-time head of the M.I.T. High-Voltage Research Laboratory, and he was also founder of High Voltage Engineering Corp. of Burlington, Mass. Shortly before his death he had been honored by Lahey Clinic when his name was given to its radiation therapy facility; Trump had a long-time collaboration with the clinic in using radiation for cancer therapy.

In addition to this work, Trump and his associates were identified with the development of new materials to withstand high electrical stress, machines for generating high electrical voltages, and various industrial uses of high-voltage discharges. At the time of his death, Trump was engaged in applying electron beam radiation to disinfect sewage sludge. If successful, this technique can make sewage safe for use as fertilizer or for land fill.

Trump came to M.I.T. in 1932 to work with Professor Robert J. Van de Graaff, whose name is given to the high-voltage generating machines upon which most of Trump's later work was based. His association with Lahey Clinic continued after retirement from M.I.T., and he had been chairman of Lahey's Board of Trustees since 1974.

Widely recognized for his varied technical contributions, Trump held the gold medal (1982) of the American College of Radiology, of which he was an honorary fellow; both honors are notable because Dr. Trump was not trained as a physician. Other awards included the National Medal of Science (1983), the Lamme Medal of IEEE (1960), and the Public Service Award of the New England Roentgen Ray Society.

Robert Woods Kennedy, 1912-1985

Architect Robert Woods Kennedy, who taught at M.I.T. for eight years beginning in 1944, died in Cambridge on January 28. He was one of the team that designed 100 Memorial Drive, an innovative skip-floor apartment plan, in the early 1950s. Since then he had maintained a private architectural practice in Cambridge.

Thomas F. McNulty, 1920-1985

Thomas F. McNulty, M.Arch.'49, who had been a member of the M.I.T. faculty from 1949 until entering private architectural practice in 1956, died unexpectedly of cardiac arrest in Boston on March 3; he was 65.

McNulty had worked on plans for the Brookline Farm Site, the Lincoln-Waltham Housing Committee, a Reintegration Center at the Norfolk Correctional Institution, and many others; perhaps his most famous design was that of his own former residence on Beaver Pond, Lincoln, Mass. At the time of his death McNulty had just completed a six-year appointment as professor of architecture at the University of Petroleum and Minerals, Dhahran, Saudi Arabia.

Rev. Myron Bloy, 1927-1985

Reverend Myron B. Bloy, Jr., who served as the first Episcopal chaplain in the M.I.T. Chapel from 1958 to 1966, died on January 27; he was 58. Bloy left M.I.T. to take the pulpit of the Episcopal church in Princeton, N.J., where he resided at the time of his death.

Ezio Tarantelli, 1942-1985

A victim of terrorists, Ezio Tarantelli, president of the Christian Democratic labor union and lecturer in political economy at Rome University, was murdered in Rome on March 27; he was 43. A student and colleague of Institute Professor Franco Modigliani (Sloan School of Management), Tarantelli had served for two years (1974-75 and 1979-80) as visiting professor at the Sloan School.

Randall G. Chipperfield, 1959-1985

Randall G. Chipperfield, a graduate student in biology, died as a result of falling through the ice of the Charles River on February 21; he was 26.

Chipperfield was crossing the river near the Longfellow Bridge in the late evening when the accident occurred; he was pulled from the water by police but later died in Massachusetts General Hospital from hypothermia.

A native of Calgary, Chipperfield came to M.I.T. from the University of Alberta in 1980. He had completed virtually all the requirements for a Ph.D. in biology with Professor Robert A. Weinberg of the Biology Department and the Whitehead Institute and had been accepted for postdoctoral work at Columbia beginning next fall. His thesis research was on a protein-caused transformation of a normal cell into a malignant counterpart—important work that was highly regarded by his teachers and colleagues.

Deceased

The following deaths have been reported to the Alumni Association since the *Review*'s last deadline:

Ralph J. Karch, '07; 1979.
Ralph E. Hyde, '12; January 25, 1985; Taunton, Mass.
George D. Anderson, '16; February 1985; Fremont, Calif.
Tredick K. Hine, '16; July 16, 1984; Huntington Woods, Mich.
Ralph H. Mills, '16; March 21, 1985; Summerland Key, Fla.
Silvio Zanetti, '16; 1976; Cambridge, Mass.
James W. O'Brien, '18; June 9, 1975.
John C. Barker, '20; January 28, 1985; Portland, Maine.
Joel A. Goldthwait, '20; February 1985; Medfield, Mass.
Chas A. Keener, '20; August 22, 1984; Champaign, Ill.
Joseph R. Mahan, '20; June 6, 1984; Perrysburg, Ohio.
Glenn E. Fargo, '21; February 25, 1985; St. Petersberg Beach, Fla.
Alfred H. Fletcher, '21; November 8, 1985; Newtown, Penn.
Mrs. Rupert M. Hanny, '21; October 1983; Chapel Hill, N.C.
Edward I. Mandell, '21; 1985; Miami, Fla.
Joseph M. Cosgrove, '22; 1985; Inverness, Ill.
Arthur H. Fischer, '22; December 3, 1984; New York, N.Y.
Spencer H. Lane, '22; 1985; Saint Paul, Minn.
Seward W. Livermore, '22; 1985; Washington, D.C.
Alan R. Allen, '23; March 1985; New York, N.Y.
Kent T. Healy, '23; January 9, 1985; Killingworth, Conn.
Robert H. Kean, '23; Alexandria, Va.
Oswin W. Lowry, '23; February 12, 1985; Holland, Mich.
Mrs. Maurice T. Crowell, '24; April 1984; Milwaukee, Wisc.
Mrs. Osborne H. Davol, '24; December 14, 1984.
John Earl Frazier, '24; January 1, 1985; Washington, Penn.
Birger Richard Headstrom, '24; February 8, 1985; Aiken, S.C.
Edison A. Lynn, '24; 1985; Dahlonega, Ga.
David A. Meeker, '24; February 22, 1985; Troy, Ohio.
Luang Videt-Yontrakich, '24; 1985; Bethesda, Md.
William M. Walterskirchen, '24; December 15, 1984; Missoula, Mont.
Howard E. Whitaker, '24; October 11, 1984; Chillicothe, Ohio.
Theodore W. Franks, '25; June 1984; Chicago, Ill.
Charles J. Kinsolving III, '25; March 14, 1984; Santa Fe, N.M.
Claus F. Kirsch, '25; December 8, 1984; Arcadia, Calif.
Henry N. Sachs, '25; February 4, 1985; New York, N.Y.

Ralph E. Brown, '26; December 24, 2984; Fairless Hills, Penn.
Robert H. Clarke, '26; November 4, 1985; Dayton, Ohio.
Thomas J. Eaton, '26; April 17, 1984; Tucson, Ariz.
William M. Smith, '26; 1985; West Hollywood, Fla.
Mrs. William Wraith, Jr., '26; 1983; Tucson, Ariz.
William T. Corey, '27; December 30, 1983; Garden City, N.Y.
Frederick J. Hooven, '27; February 5, 1985; Norwich, Vt.
Roger M. Pierce, Sr., '27; January 10, 1985; West Brookfield, Mass.
Charles M. Anderson, '28; December 1984; Gloster, Miss.
Albert E. Beitzell, '28; February 3, 1985; Bangor, Maine.
Harold A. Harrington, '28; July 16, 1984; Cambridge, Mass.
Albert H. Shedd, '28; 1985; Molalla, Ore.
Richard S. Smith, '28; September 24, 1984; Sacramento, Calif.
Marshall H. Fay, '29; February 8, 1985; Port Washington, N.Y.
Harold H. Theiss, '29; 1983.
Edward D. Thomas, '29; February 1, 1985; Foxboro, Mass.
Claude C. Cash, '30; July 25, 1984; Hohokus, N.J.
Richard B. Ellis, '30; March 5, 1985; Athol, Mass.
John C. Larkin, '30; February 3, 1985.
Fred L. Markham, '30; 1985; Provo, Utah.
William Wallace McDowell, '30; March 2, 1985; Naples, Fla.
Myron T. Smith, '30; February 18, 1985; South Casco, Maine.
William, E. Yelland, '30; January 27, 1985; Southborough, Mass.
Paul A. Davis, '31; December 1, 1983; Vero Beach, Fla.
Herman H. Ferre, '31; February 1985; Ponce, P.R.
Robert M. Kelly, '31; January 30, 1985; Orleans, Mass.
Manuel Schivek, '31; July 31, 1984; Randolph, Mass.
Charles R. Wood, '31; September 9, 1984; Kennett Sq., Penn.
Earl F. Anderton, '32; November 27, 1984; Bellevue, Wash.
Mrs. Amy V. Higgins, Jr., '32; 1982.
G. Edward Nealand, '32; March 19, 1985; Sandwich, Mass.
George W. Palmer, '32; December 20, 1984; Falmouth Foreside, Maine.
Sterling N. Slockbower, '32; 1985; South Plainfield, N.J.
Walter R. Duncan, '33; January 20, 1985; Rosemont, Penn.
Henry E. Kiley, '33; September 1984; Chatham, N.J.
Harold H. Okasaki, '33; 1984; Gardena, Calif.
John G. Trump, '33; February 21, 1985; Winchester, Mass.
Arthur E. Byerlein, '34; 1982; Tucson, Ariz.
Robert M. Elliott, '34; December 14, 1984; Norwich, Conn.
David L. Foulkes, '34; January 23, 1985; Oakland, Calif.
Alton C. Garland, '34; January 1, 1985; Sandwich, Mass.
Horace A. Giddings, '34; December 11, 1984; Daytona Beach, Fla.
James R. Higgins, '34; October 18, 1984; Kansas City, Mo.
William W. Buechner, '35; March 12, 1985; Arlington, Mass.
George R. Bull, Jr., '35; December 9, 1984; Wayne, Penn.
Luis A. Dastas, '35; 1985; Miami, Fla.
Richard K. Anderson, '36; 1985; Sumter, S.C.
Charles L. Austin, '36; 1984; Sun City, Ariz.
William Fingerle, Jr., '36; December 6, 1984; Old Greenwich, Conn.
Carlyle W. Jacob, '36; February 18, 1985; Quincy, Mass.
George B. Payne, '36; June 28, 1984; Bacliff, Tex.
G. Elliott Robinson, '36; March 30, 1985; Hanover, Mass.
Annis G. Asaff, '37; March 1983; Lincoln, Mass.
Robert L. Carlisle, '37; 1985; Bayside, N.Y.
Peter Kolupaev, '37; January 24, 1983; Philadelphia.
Abraham Schwartz, '37; February 4, 1984; Englewood, N.J.
Arthur B. Savel, '38; January 10, 1985; Brookline, Mass.
Peter E. Kyle, '39; December 6, 1984; Northfield, Vt.
Parks R. Toolin, '39; 1985; Pittsburgh, Penn.
William C. Walker, '39; January 27, 1985; Lexington, Mass.
Bernard Carver, '40; 1985; Winthrop, Mass.
Nils M. Rosenberg, '40; January 20, 1985; Seattle, Wash.
Louis Strymish, '40; 1985; Newton Center, Mass.
Nicholas Williamson, '40; January 20, 1985; Pocasset, Mass.
Preston R. Glading, '41; December 16, 1984; Barrington, R.I.
Peter Homack, '41; December 1984; Palm Beach, Fla.
Samuel L. Solar, '41; June 1984; San Jose, Calif.
Robert W. Curtis, '42; November 27, 1984; Arlington, Va.
David F. Kinert, '42; 1985; Burlingame, Calif.
John W. McNall, '42; July 10, 1984; Greensburg, Penn.
Maynard D. Lee, '44; January 3, 1985; Kittery, Maine.
Leonard T. Loforese, '44; December 13, 1984; Greenwich, Conn.
Hugh M. Jansen, Jr., '45; February 25, 1984; Atlanta, Ga.
Edward V. Oxenford, '45; February 4, 1985; Buenos Aires, Argentina.
Edward J. Fradkin, '46; February 10, 1985; New York, N.Y.
Frederick M. MacDonald, '46; January 8, 1985; Hyannis, Mass.
Walter H. Amadon, '48; October 26, 1984; Sudbury, Mass.
James Dugundji, '48; January 8, 1985; Los Angeles, Calif.
Peter W. Johnson, '48; 1985; San Jose, Calif.
Mrs. Paul Dulaney, '49; January 1985; Glade Spring, Va.
William Haddon, Jr., '49; March 4, 1985; Bethesda, Md.
Worley B. Lynn, '49; 1984; Vian, Okla.
Eugene A. Morgan, '49; March 14, 1985; Bedford, N.H.
Axel Erik Nygren, '51; January 8, 1985; Fagersta, Sweden.
Sergej Zezulin, '52; February 2, 1985; Sea Cliff, N.Y.
William E. Sollecito, '53; November 2, 1984; Syracuse, N.Y.
John B. Padgett, Jr., '54; July 16, 1984; Palos Verdes, Calif.
David R. Wones, '54; December 1984; Blacksburg, Va.
William B. Banks, '55; February 23, 1985; Port Orange, Fla.
Thomas C. Wood, '55; April 19, 1984; Manhattan Beach, Calif.
Robert R. Pollard, '56; January 29, 1985; Hollis, N.H.
Harry M. Salesky, '57; 1985; Tiburon, Calif.
Robert Van Benschoten, '57; March 15, 1984; Livingston, N.J.
Donald Daryl Wyckoff, '58; January 20, 1985; Marblehead, Mass.
Bruce R. Hayworth, '59; January 20, 1985; Poway, Calif.
Maciej James Achmatowicz, '64; October 28, 1984; Ashburn, Canada.
Ralph W. McKenney, Jr., '66; January 18, 1985.
Stanley D. Derbin, '69; November 29, 1984; Danbury, Conn.
Kenneth R. Britting, '71; February 18, 1985; Dover, Mass.
Omer S. Kaymakcalan, '75; February 22, 1985; Dewitt, N.Y.
David A. Anderson, '76; February 22, 1985; Haworth, N.J.
Wayne E. Matson, '77; February 1985; Boston.
Randall G. Chipperfield, '85; Cambridge, Mass.
Karl N. Horita, '85; January 25, 1985; Brookline, Mass.

ALLAN J. GOTTLIEB

Great Climbing Monkeys!

This past week I was quite ill with a flu-like disease that caused me to miss my first three days of work since arriving at NYU more than five years ago. And guess who strolled into the lab to interview our research group while I was out: the CBS Evening News! I guess it just doesn't pay to get sick so often.

I am sorry to say that, for some unexplained reason, *two* of the October solutions given in the February/March issue were unattributed. Somehow between my original manuscript and the final column, credits to Harry Zaremba and David Griesedieck for **OCT 2** and **OCT 4**, respectively, were omitted. I apologize for the error.

Finally, I would like to acknowledge a touching letter from one of the most active contributors to Puzzle Corner who explained, in a warm and personal way, why his activity would have to decrease. This column is dedicated to John Rule.

Problems

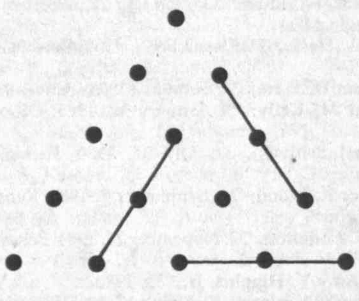
JUL 1. For our computer problem of the month, Matthew Fountain wants you to find the smallest prime number that contains all 10 digits.

JUL 2. Lester Steffens asks us to answer a new question about the widely known Tower of Hanoi problem:

The original tower, first described in 1883, consisted of 64 golden discs, each of a different diameter, stacked according to size, with the smallest on top. The tower is to be restacked on one of two additional sites, moving one disc at a time off the top of one stack either to an empty site or to the top of the stack on one of the other sites, without ever placing a larger disc on a smaller. The original problem was to find the minimum number of moves to transfer the entire stack. The new problem is to calculate the location of each disc after 1,001 moves have been made using the optimum transfer procedure.

JUL 3. Charles Bostick has some points that need to be covered:

Define an n-triangle to be a collection of n(n + 1)/2 points regularly spaced into the shape of an equilateral triangle with n points on a side. Define a 3-line to be a line segment connecting exactly three adjacent points parallel to a side of an n-triangle. (The three adjacent points are said to be "covered" by the 3-line). For what values of n can all points of an n-triangle be covered by non-intersecting 3-lines?



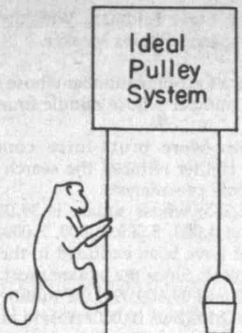
JUL 4. Here is one from a batch John Rule sent me in 1974 and I have been periodically milking ever since:

A manufacturer makes all possible sizes of brick-shaped blocks such that the lengths of the edges are integral multiples of the unit of length, and that the number of units in the total length of the twelve edges of the block is equal to two-thirds of the number of units of volume in the block. What sizes does he make?

JUL 5. Here is some monkey business from Bruce Calder:

An ideal pulley system supports a bucket of water on one rope and a monkey on the other. The bucket and monkey are in static equilibrium and at the same vertical level. Suddenly the monkey began climbing up its rope. Describe the motion, if any, of the bucket.

SEND PROBLEMS, SOLUTIONS, AND COMMENTS TO ALLAN J. GOTTLIEB, '67, ASSOCIATE RESEARCH PROFESSOR AT THE COURANT INSTITUTE OF MATHEMATICAL SCIENCES, NEW YORK UNIVERSITY, 251 MERCER ST., NEW YORK, N.Y., 10012.



Speed Department

SD 1. Phelps Meaker is building a straight sidewalk 54′8″ long, using 40 cast-concrete slabs each formed as an equilateral triangle. To square off the ends, he has two extra 30-60-90 half-slabs. What is the width of the walk?

SD 2. A bridge quickie from Doug Van Patter:

Your hand:	*Dummy:*
♠ A K 10	♠ J 5 3
♥ A Q J 10 7 2	♥ 9 6 5
♦ K	♦ A J 7 4
♣ A J 10	♣ Q 6 2

Your contract is six hearts. West leads a low club. You put in the ♣Q, which is covered by the ♣K and ♣A. Can you find a line of play that just about guarantees success?

Solutions

FEB/MAR 1. Management meetings are scheduled on the second Thursday of each month, administrative conferences are the third Friday, and work units have a seminar on the first Monday. Derive an alogrithm which will generate a date given the year, month, day-of-week, and ordinal week within the month. For example, if a meeting were scheduled for the third Friday of August 1984, the algorithm would return "August 17." Note that a meeting on the fifth Tuesday in March would be fine for 1983, 1985, and 1986 but not for 1984 (there are only four Tuesdays in March of 1984). In this case the algorithm could return January 0.

The following solution is from Al Weiss, who also notes that there are only four Tuesdays in March in 1985 and 1986:

Programmers, like all good craftsmen, have their own bags of tools. One tool that has been in my bag for a long time is a routine that will convert a date into the number of days since November 24, −4713 (this is not the same as 4713 B.C., since there was no year zero). The number generated by this routine is called the Julian day. It is similar to a "shop date," which is the number of days since the beginning of the year. This number itself is not too useful, but it can be used to calculate the number of days between two dates. There is also a companion routine which converts the number back into a date. These two routines can be used of find the date 90 days from today. Using these two routines it is possible to solve Alfred Anderson's problem. My procedure is as follows:

1. First we determine the Julian Day of the 1st of the month desired (assuming we are looking for the third Friday in July 1985, this would return the number 2446248).
2. We then determine what day of the week this is (in this case the program returns a 1 telling us that this is a Monday). Next we find the date of the first Friday (the computer tells us that this is the 5th).
3. Then we calculate the date of the 3rd Friday (in this case the 19th).
4. Finally the program validates the answer by calculating the Julian day of this date and then reconverting the Julian day back to a real date. If the month of this new date is the same as the original month, we have a solution. As an example of an impossible date: if we were looking for the 5th Friday in July, the computer would calculate it to be the 33nd of July. When this is converted to a Julian day and then back to a real date it comes back as August 2nd. The computer recognizes that August is not the month requested and sets the date to zero.

Mr. Weiss submitted the program described above, but inadequate space prevents us from reprinting the program and we apologize. A copy can be had by return mail from the *Review*.

Also solved by Frank Carbin, Harry Zaremba, Jim Landau, John Patterson, Matthew Fountain, Robert Slater, Winslow Hartford, and James Abbott (who also included a TI-59 program card containing his solution.)

FEB/MAR 2. Two coins, loosely coupled, are flipped simultaneously such that if either one is heads, the other has probability 7/8 of also being heads, but if either one is tails, the other is equally likely to be either heads or tails. Find the probability of each individual coin turning up heads, and the probability of their both being heads simultaneously (or prove that the problem statement and data are inconsistent).

Michael Tamada found a couple of solution techniques for the loosely coupled coins:

Each coin has probability of .8 of being heads. The probability that both are heads is .7:

		Coin 2 H	Coin 2 T	
Coin 1	H	.7	.1	.8
	T	.1	.1	.2
		.8	.2	

I have two ways of deriving the answer, one using a "contingency table" approach and one using a "conditional probability" approach.

Contingency Table Approach:

We wish to find the unknown probabilities a, b, c, and d:

		Coin 2 H	Coin 2 T
Coin 1	H	a	b
	T	c	d

We know that a + b + c + d = 1. If Coin 1 is tails (i.e., if we're in the second row, which contains c and d), we are told that Coin 2 has equal probabilities of being heads or tails. In other words, c/(c + d) = 1/2. Similarly, if Coin 2 is tails, we are told that b/(b + d) = 1/2. These two equations tell us that b = c = d, so we know that a + 3b = 1. We are told that if Coin 1 is heads, then Coin 2 has a probability of 7/8 of being heads. In other words, a/(a + b) = 7/8. Substituting a = 1 − 3b in the above equation, we get (1 − 3b)/(1 − 3b + b) = 7/8, or b = .1. Since b = c = d, we know c = d = .1 and thus a = .7.

Conditional Probability Approach:

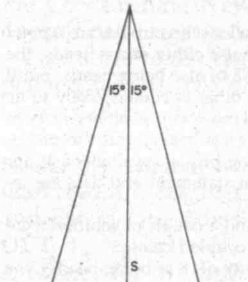
Let "H1" and "T1" stand for the probability that Coin 1 is heads or tails respectively. Obviously H1 = 1 − T1 (and H2 = 1 − T2 for Coin 2). Let p(H1:H2) stand for the probability of event H1 given that H2 occurs. We are told that p(H1:H2) = 7/8 and p(H2:H1) = 7/8. Similarly, we are told that p(H1:T2) = 1/2 and p(H2:T1) = 1/2. The unconditional probability of any event is equal to the sum of its conditional probabilities (weighted by the

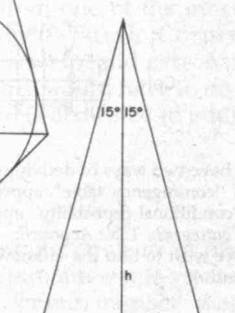
probabilities of the condition occuring). I.e.,
$p(H1) = p(H1{:}H2) \times p(H2) + p(H1{:}T2) \times p(T2)$.
So
$p(H1) = (7/8)p(H2) + (1/2)[1 - p(H2)]$
$p(H1) = 1/2 + (3/8)p(H2)$. (1)
Similarly, for Coin 2 we get
$p(H2) = p(H2{:}H1) \times p(H1) + p(H2{:}T1) \times p(T1)$
$p(H2) = (7/8)p(H) + (1/2)[1 - p(H1)]$
$p(H2) = 1/2 + (3/8)p(H1)$. (2)
Combining equations (1) and (2),
$p(H1) = 1/2 + (3/8)[1/2 + (3/8)p(H1)] = 4/5$.
We also find that $p(H2) = 4/5$. Again using laws of conditional probability, we know that
$p(H1 \,\&\, H2) = p(H1{:}H2) \times p(H2) = 7/8 \times 4/5 = .7$

Also solved by David DeLeeuw, Leon Tabak, Matthew Fountain, Michael Jung, Richard Hess, Winslow Hartford, and the proposer, William Stein.

FEB/MAR 3. A horizontal line of length 2a forms the common base for two isosceles triangles. The near side the triangle is 45° −45° −90°, and on the opposite side 75° −75° −30°. Determine the radius of the circle tangent to all sides of the composite lanceolate figure, and locate the center.

Avi Ornstein makes it look easy:





Let x be the radius of the inscribed circle, let h be the line segment from the circle's center to the vertex of the 75° −75° −30° triangle, and let s be the length of the bisector of this triangle. From the diagram, we see:
$s = a/\tan 15°$ and $h - x/\sin 15°$
$a + s = x2^{1/2} + h$.
Thus we have
$a + a/\tan 15° = x2^{1/2} + x/\sin 15°$
$x = a(1 + 1/\tan 15°)/(2^{1/2} + 1/\sin 15°)$
$x = 0.896575472a$
$x2^{1/2} = 1.267949192a$

Also solved by David DeLeeuw, Everett Leroy, George Parks, Harry Zaremba, Mary Lindenberg, Matthew Fountain, Mel Garelick, Naomi Markovitz, Richard Hess, Steve Feldman, Winslow Hartford, and the proposor, Phelps Meaker.

FEB/MAR 4. Find a four-digit number whose square is an eight-digit number whose middle four digits are zero.

Most solutions were brute-force computer searches. Pierre Heflter reduced the search vastly by employing some pre-analysis:
The answer is 6,245, whose square is 39,*000*,025. Trivial answers of 4,000, 5,000, 6,000, 7,000, 8,000 and 9,000 should have been excluded in the statement of the problem. Since the square must lie between 10,*000*,001 and 99,*000*,099, the number itself must lie between 3,163 and 10,000. Absent any way to predict the occurrence of zeros in the middle of a square, one could square each number between 3,163 and 10,000 (6,144 numbers in all if endings in zero are omitted) and hope to find a square with four zeros in the middle. A tedious search without a computer, almost two hours on my HP97. For a more efficient search, consider the following: the square root of 10,*000*,099 is 3,162.293; the square root of 10,*000*,000 is 3,162.277. The difference is 0.0156. In the same test for numbers 99,*000*,099 and 99,*000*,000, the difference in square roots is 0.00498. It follows that if X is a number ranging up from 10,*000*,000 and if $\sqrt{X}$ comes out with a fraction which is more than 0.0156, there is no number between X and X − 99 which is a perfect square. So, using 0.0156 as a discriminant, take the square root of 90 numbers of the form ab,*000*,099, where ab ranges from 10 to 99 (easy on any pocket calculator), discard any square root if its fractional part exceeds 0.0156, and round out the rest to the next lowest whole number. Then discard any left that end in zero. Three remain that are worthy of being tested. One of them, 6,245, satisfies the problem. The other two do not because the discriminant did not decrease to 0.00498 (as it should have to be a necessary *and sufficient* test) as ab ranged up to 99. This search took just over two minutes on my HP97.

Also solved by Jerry Cogan, Frank Carbin, Chester Claff, Avi Ornstein, Dennis Sandow, George Byrd, George Parks, John Prussing, Lee Fox, Matthew Fountain, Michael Jung, Michael Tamada, Naomi Markovitz, Nicholas Strauss, Richard Hess, Robert Slater, Robert Turner, Ronald Raines, Thomas Stowe, and Winslow Hartford.

FEB/MAR 5. Consider two dipoles. The lower dipole is fixed, and the upper dipole is constrained to move along a horizontal line. (This is roughly the geometry encountered in magnetic stirring.) Find the conditions for which the upper dipole tends to center (the force is in the opposite direction to the displacement from the center line). When does the motion of the upper dipole approximate simple harmonic motion?

Only Matthew Fountain and Richard Hess tackled this hard problem. Mr. Fountain's impressive solution would have been published except for a confrontation between its length and the available space in this issue. Readers may obtain a copy (together with our apologies, which go also to reader Fountain) by return mail on request to the *Review* office.

Better Late Than Never

JAN 4. Pierre Heftler has responded.

Proposers' Solutions to Speed Problems

SD 1. 27.733

SD 2. First cash the ♦K, then lead the ♥Q. If this holds (it did) and both defenders follow suit, play the ♥J. Presumably, a defender will take the ♥K. Now the ♥9 provides an entry to dummy, and you can pitch the ♠10 on the ♦A. If East shows out on the first trump trick, play a small trump toward the ♥9, with the same result. This hand occurred at the Talleyville Club in Wilmington, Del., which boasts of the highest percentage of life masters in the U.S. West actually held three hearts to the king. Several declarers made 12 tricks.

Collective research could enable firms to "freeze out" innovative, aggressive mavericks.

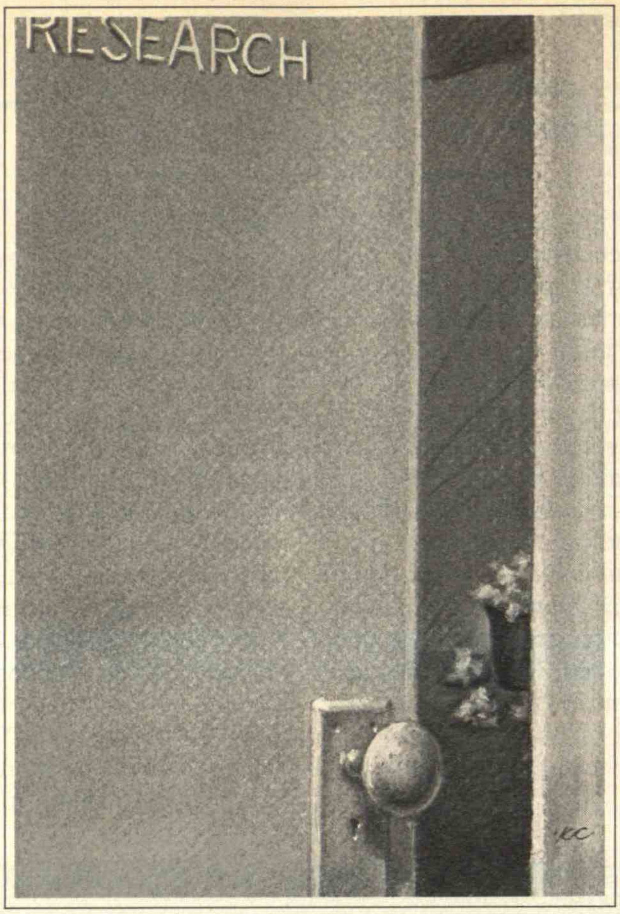
companies conspired to delay the date at which the regulations could take effect because they feared that their customers would be loath to pay for the emission controls. The suit was settled through a consent decree, without admission of guilt—a settlement in which the companies in effect said that "we never did anything wrong and we'll never do it again."

Collective research can have two other ill effects. A cooperative may unduly narrow its members' research focus—the other side of the coin to "avoiding wasteful duplication." And pooling their efforts may dull members' competitive initiative in conducting research. Under an agreement in which each firm undertakes its own research but agrees to share the results with the rest of the group, for example, no company will be able to gain a competitive edge. The agreement among the auto manufacturers on emission-control technology was, arguably, such an arrangement.

The Antitrust Laws

The antitrust laws are the primary legal means for attacking and limiting anticompetitive practices. For collective research, the keys are a few short paragraphs in the Sherman Act of 1890. Section 1 of the act states that "every contract, combination . . ., or conspiracy, in restraint of trade or commerce . . . is declared to be illegal." According to section 2, "Every person who shall monopolize, or combine or conspire with any other person, to monopolize . . . trade or commerce . . . shall be deemed guilty." The act carries both criminal and civil penalties.

The Justice Department's Antitrust Division is the primary agency for enforcing the act. (The Federal Trade Commission tends to focus its efforts on other parts of the antitrust laws.) The division usually brings criminal suits only in egregious cases of price-fixing or monopoly, in which the defendants knew



or should have known that their activities were illegal. In these instances, which also include cases where companies rig bids and divide up markets in the infamous smoke-filled rooms, the division generally asks for jail sentences and stiff fines against the guilty parties. In the early 1960s, for example, several executives from General Electric and Westinghouse served time for setting the prices of electrical generators and switch gears. More recently, executives of many construction firms have ended up in jail for rigging bids on highway construction projects.

When the anticompetitive nature of the practices is more open to question, the division brings civil cases, asking the court to halt the practices and to take measures to reduce the likelihood that they will recur. The well-publicized cases brought against IBM, that was dropped in 1982, and AT&T, settled on the same day, typify that approach.

Private citizens and companies can also bring civil suits under the Sherman Act. If such plaintiffs can prove that the defendants caused them injuries as a direct result of violating the act, the court will enjoin the actions and require the defendant to pay the plaintiff three times the level of damages proved. It is the fear of such private treble-damage suits, combined with the apparent breadth and vagueness of the Sherman Act, that has apparently led to the widespread belief that antitrust laws are inhibiting collective research.

However, to my knowledge, no plaintiff has ever won a case against a member of a collective-research effort. Even so, potential members and their cautious antitrust attorneys might well fear that a federal district court judge or jury could decide that their cooperative research constitutes a "contract, combination . . ., or conspiracy in restraint of trade" or an "attempt to monopolize." The unsettled and untested state of the law tends to heighten such fears. In these circumstances, threats to sue can be potent.

Analyzing the Legalities

In fact, the Sherman Act's language appears broader than it really is. Every contract or agreement between two companies restrains the companies in some manner and thus restrains trade. But the vast majority of contracts are not attacked as anticompetitive. Indeed, by increasing certainty and reducing risk they enhance the efficiency with which firms can use resources, and thus their ability to compete in the marketplace. It is agreements that *unreasonably* restrain trade—such as those to fix prices, allocate markets, or raise the costs of rivals—and clear attempts by one or a few firms to corner a market that have generally come under antitrust scrutiny in the courts.

The antitrust laws should be seen as a means of encouraging competition so as to improve long-run economic efficiency and welfare. A long-run view of the incentives for firms to compete and excel is crucial. Short-run efforts to protect individual competitors clash with these long-run goals. I would argue that only those arrangements interfering with the long-range competitive process should be considered unreasonable and subject to the Sherman Act. The potential for harm should, when possible, be based on empirical evidence rather than *a priori* judgments.

Over the last two decades the Antitrust Division has been gradually moving toward such an emphasis on long-term consequences. The process was hastened considerably by the arrival of William Baxter as head of the division in the spring of 1981. He repeatedly insisted on broadening the analysis of arrangements such as collective research that might appear to be anticompetitive but that need not be.

This approach entails identifying and analyzing a particular market to determine the likelihood of anticompetitive behavior. For antitrust purposes, a market is the smallest group of sellers who, acting collaboratively, could raise prices significantly without being thwarted if too many customers switch to

Competitive rivalries will surely limit the extent of collective research and the gains from it.

other sellers. The likelihood of noncompetitive behavior increases with:

☐ The fewer the number of firms in a market.

☐ The greater the differences in the firms' sizes.

☐ The greater the difficulty of new firms in entering the market and that of existing (especially, small) sellers in expanding their share.

☐ The larger the number of buyers, and the lower the concentration among them.

☐ The greater the standardization and simplicity of the product.

For example, if only a few firms are selling a standardized product, such as aluminum ingots, to a large number of buyers and entry by new sellers is difficult, the likelihood that the few sellers would recognize their joint benefit in competing less aggressively would increase. These principles can be used to analyze the potential anticompetitive effects of a merger among producers of more tangible goods and services as well as of a collective-research effort.

If the antitrust concern is about the effects of collective research on an industry's overall competition, the relevant product and geographic markets of the firms should be defined. This analysis should include the effect of actual or potential imports on the market, except where they are blocked by, say, quotas.

If the legal concern is that collective research will impair competition in R&D itself, the market for that research must be defined. This market is probably broader than that for goods, for three reasons. First, both customer and supplier firms may participate in research on an industry's technological problems. For example, not only the can industry but also aluminum companies and soft-drink firms would be interested in improving the technology of extruding aluminum soft-drink cans. Second, overseas companies may participate in cooperative research even when transportation costs or other trade barriers prevent the firms from actually selling their products in the United States. Technology is often easier to transport than products. Many U.S. companies license technology from companies abroad, and vice versa, even though the firms do not export or import the goods themselves. Third, a wide range of industries and firms may be interested in basic research.

Once the research market is defined, its structure and the nature of the collective research must be determined. That information makes some competitive issues easier to settle.

If the members of a collective-research effort account for a small fraction—say 15 to 20 percent—of the market, the potential for stifling competition would appear to be slight. Such a cooperative could hardly dampen the pace of the industry's overall research, and mavericks could form their own collectives. If the market is unconcentrated or open to entry, even cooperative research that includes most or all sellers would probably threaten little harm. And if the details of the cooperative arrangement are not restrictive—members may also conduct their own research, for example—competitive concerns are unlikely to be severe.

Even if the underlying market is concentrated and difficult to enter, and a cooperative-research effort includes most sellers, competition will not necessarily suffer. In this case, the potential benefits from the arrangement must be weighed against the potential risks to competition. In addition, if economies of scale dictate that research must involve a high proportion of firms in a market—responsible, say, for more than 50 percent of overall sales—then one can argue that all the other firms in the market should be allowed to join. However, such requirements should be used carefully and sparingly.

Plainly, this type of analysis cannot eliminate all the problems in deciding whether specific examples of collective research are anticompetitive. But it does provide a framework for considering the difficult cases as well as identifying the easy ones. The Antitrust Division's decision not to oppose the formation of MCC, for example, was made much simpler by the absence of computer-industry giants IBM and AT&T from the consortium, and by the active rivalry of Japanese producers in this research.

How Effective Is Collective Research?

While Baxter indicated in 1981 that collective research would not automatically be suspect as anticompetitive, political pressures continued to mount for legislation to allay fears that firms would be prosecuted for such research. The result was the National Cooperative Research Act, passed by Congress last September and signed into law in October.

The act contains four important provisions. First, it permits—but does not require—the parties in a collective-research venture to register with the Antitrust Division and the Federal Trade Commission. Second, any private plaintiff who wins an antitrust suit against a registered collective-research venture can receive only the actual amount of damages,

So far cooperative research shows little evidence of leading a new industrial revolution.

rather than treble damages. Third, courts handling antitrust suits must use a "rule of reason" standard to judge the legality of cooperative research. This means that they must weigh the potential benefits of the research—in improving efficiency, for example—against its possible anticompetitive effects. Finally, the act allows research collectives that successfully defend themselves against antitrust suits to force plaintiffs to pay the legal fees if the suit is deemed "frivolous, unreasonable, without foundation, or in bad faith." Defendants usually cannot win reimbursement from plaintiffs in other antitrust cases.

The new law is a sensible step in reducing antitrust fears and encouraging collective research that will enhance efficiency and competition in the U.S. economy. But how significant will that effect be? Policymakers in Congress and the Reagan administration have promoted joint research as the salvation for the U.S. economy. That view now seems wildly optimistic.

So far cooperative-research ventures show little potential for ushering in a new industrial revolution. A recent survey by the Center for Science and Technology Policy at New York University's Graduate School of Business Administration shows five major categories of organizations that do cooperative research:

☐ Trade associations, such as the Chemical Manufacturers Association and the American Petroleum Institute.

☐ Industry associations established specifically to fund or conduct research programs. The Semiconductor Research Corp. of Research Triangle Park, N.C., and the Electric Power Research Institute (EPRI) based in Palo Alto fall into this category.

☐ Subject-specific centers based at universities. These use seed money from the federal government, such as the Center for Research on Polymers at the University of Massachusetts, or from interested companies, such as the Stanford University Center for Integrated Systems.

☐ Independent research institutes funded by companies to make nonproprietary technical advances and apply research related to "the public welfare." The Sulphur Institute and the Chemical Industry Institute of Toxicology are examples.

☐ Independent institutes with a dual focus on education and research, established by an industry to address its labor needs and do nonproprietary research. The Institute of Paper Chemistry, an accredited degree-granting institution, and the Textile Research Institute, affiliated with Princeton University, are archetypes.

In general, organizations involved in these and other cooperative-research ventures have annual budgets of only a few million dollars. The main exceptions are the Bell Communications Research Organization, formed by the now independent Bell companies, with a yearly budget of about $880 million; EPRI ($350 million); the Gas Research Institute ($130 million); and MCC ($50 million). But the money spent on cooperative research is small change compared with the overall funding for R&D in U.S. industry. The total budgets of all 59 collective-research efforts that the NYU study could track down came to 1.2 percent of total industry R&D in 1982 and 3 percent in 1984—and the Bell effort alone was well over half the latter figure.

That investment will probably produce enough modest advances to justify the easing of antitrust regulations for cooperative research. And reducing antitrust concerns will undoubtedly encourage firms to initiate such ventures. But companies' fears of giving away technical secrets to rivals, the fact that many firms do not feel the need for collective research, and the difficulties of staffing and running a joint-research effort among competitors will surely limit the extent of these ventures and the gains they make.

In the six months after the National Cooperative Research Act became law, fewer than 20 such collectives registered with the Antitrust Division and the FTC to obtain protection against treble damages. Even an insider has admitted that removing the legal barriers will not stimulate a flood of cooperative research. "R&D is tremendously expensive, and it is getting more expensive every year," said Larry W. Sumney, president of the Semiconductor Research Corp., a consortium of electronics companies that funds university research. "The question now isn't how much joint research is legal; it's how much the industry can afford." At best, these efforts will yield only minor gains in productivity. Cooperative research has neither the potential nor the financial backing to be a panacea for the U.S. economy.

LAWRENCE J. WHITE is professor of economics at New York University's Graduate School of Business Administration. He recently spent 19 months as the chief economist in the Justice Department's Antitrust Division.

39% OF ALL HIGH SCHOOL SENIORS ARE PROBLEM DRINKERS.

Your local United Way supports a range of alcoholism prevention and treatment agencies that work together to solve teen-age alcoholism and many other social problems.

With your help we're also trying to do something about domestic violence, offer support services for single household families, provide rehabilitation for victims of crippling diseases. And more.

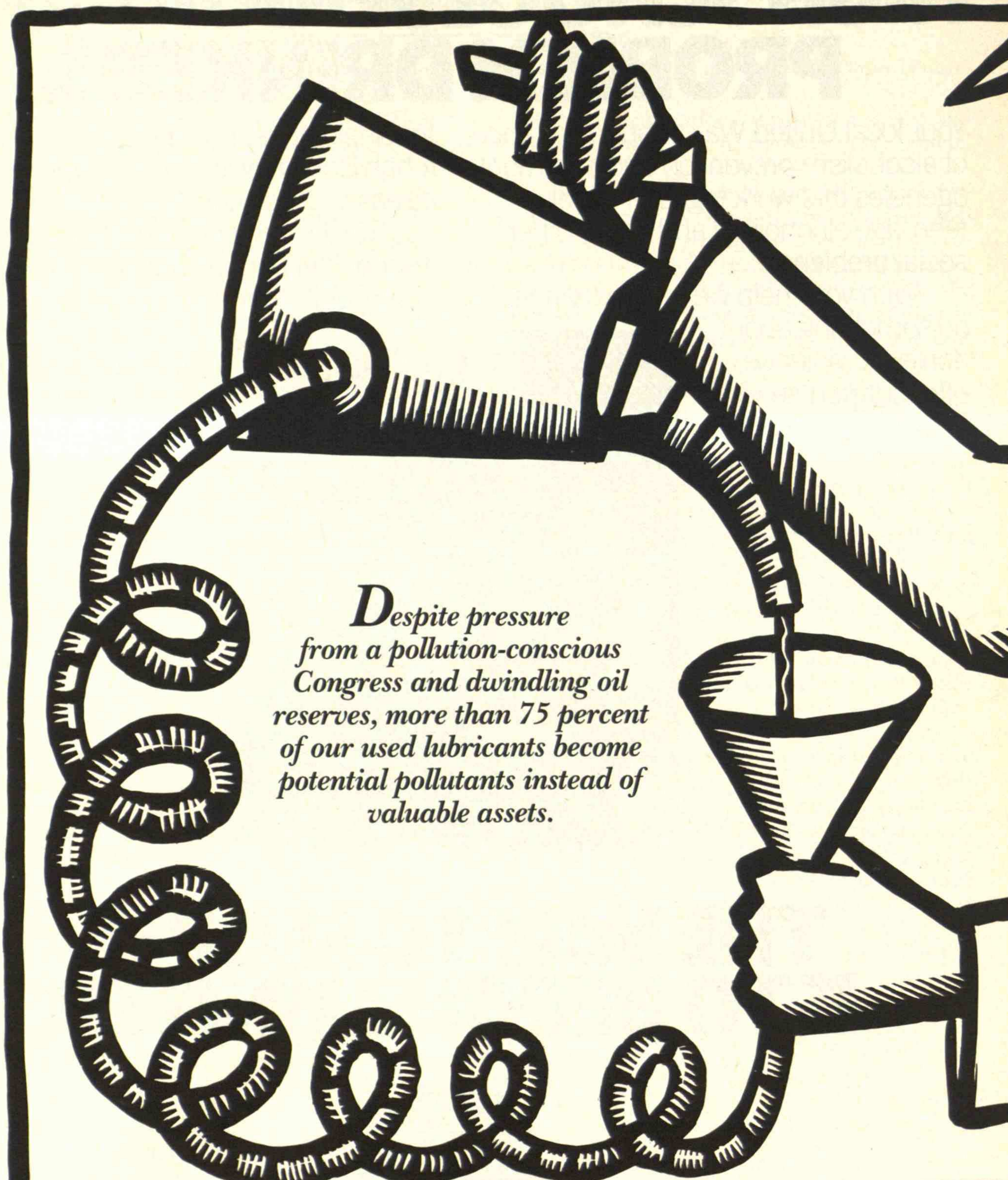
But we can't do it without you. Your one gift helps more people in your community than any other way of giving.

So give generously. Because together we can do anything.

THE WAY TO STOP IT IS TO BECOME UNITED.

United Way

Thanks to you it works for all of us.



Despite pressure from a pollution-conscious Congress and dwindling oil reserves, more than 75 percent of our used lubricants become potential pollutants instead of valuable assets.

Used Oil: Resource or Pollutant?

BY DENNIS W. BRINKMAN

MORE than half of U.S. car owners now change the lubricating oil in their vehicles themselves at least once a year, draining from their cars' crankcases some 350 million gallons of used oil. Perhaps 15 percent of this material is recovered for reuse as lubricant or fuel; most of the rest is disposed of in ways that ultimately bring it into the environment as a pollutant.

In all, more than 1 billion gallons of used lubricants are generated in the United States annually. Despite the fact that these are among the highest-quality products refined from our best crude oils, only about 100 million gallons reach recyclers to be re-refined into clean lubricants. The rest is burned as a fuel or disposed of as a waste, too often improperly. Indeed, a conservative estimate is that over 500 million gallons of used lubricating oil are annually injected directly into the environment through landfills and other disposal methods.

These valuable products could be recovered for reuse—made essentially as good as new—for a relatively low additional investment in time, money, and energy. Recycling could also significantly reduce pollution risks. But even recovery for reuse or burning does not insure proper management. Improperly handled waste oil or its constituents, collected by recycling companies, figure in many sites that now await cleanup under the "Superfund" program of

ILLUSTRATION: ANTHONY RUSSO

the Environmental Protection Agency (EPA).

We continue to await regulatory initiatives that will rationalize our handling of this material. EPA has now begun the process of issuing regulations covering the burning of used lubricants as fuel, and will eventually propose regulations covering re-refining. Meanwhile, the question remains of whether to declare used lubricants a hazardous waste—a ruling that would impose new constraints on the recycling industry while emphasizing the importance of proper handling by the rest of us.

Where used lubricants come from

Putting "Ma and Pa" Out of Business

The idea of recycling petroleum-based lubricants has surfaced whenever there has been a scarcity of oil, or even the threat of scarcity. The first concerted efforts at recycling were made during World War I. With renewed interest during World War II, the recycling industry prospered and grew in the 1940s and 1950s. By 1960 150 companies were producing over 300 million gallons of recycled lubricants a year. Then the industry began to languish because of changes in technology.

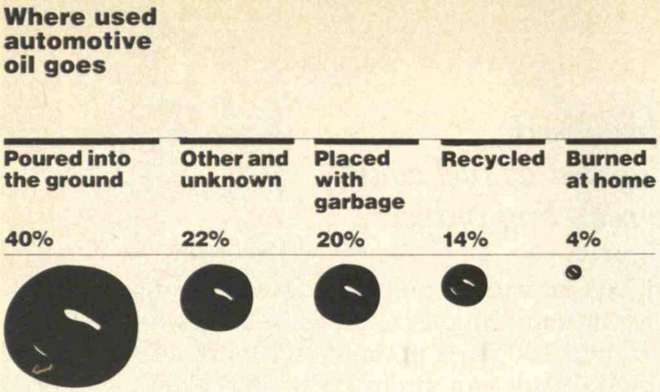
At the end of World War II, lubricants were derived almost completely from crude oils. Additives such as detergents used to enhance performance represented only a small percentage of the total volume. In contrast, the additives in today's automotive lubricants may represent 25 percent of the volume. As a result, the lubricants perform as light oils when cold and as heavy oils when hot, and they can be used for up to 15,000 miles in a typical automobile engine. That's fine for the car owner. But the complex chemistry that keeps dirt and sludge in suspension for 15,000 miles makes decontaminating and reclaiming the lubricant a far more sophisticated chemical problem.

Similar developments have affected industrial lubricants, with two more changes. Many are now used in the form of oil/water emulsions, and many manufacturers now use advanced filtering techniques to make the lubricants last longer, so that they are removed for disposal only when heavily contaminated. These two practices make recycling of these fluids more difficult and economically less attractive.

The oil crisis of the 1970s once more gave new life to the industry. Technical interest in recycled lubricants suddenly increased, with over 1,200 reports, patents, and other publications on this rather narrow subject appearing in less than a decade.

Since then, for reasons as diverse as its participants, the industry has been in steady decline. Indeed, the diversity of the participants has been one of the major problems. Until the 1970s, almost every company involved in collecting, recovering, and redistributing waste oils was a small business. "Ma and pa" operations were at least as common in used-oil recycling as in the corner-grocery business. Though these recycling companies often had low overhead, many were undercapitalized. As the lubricants became more sophisticated and environmental regulations began to require proper disposal and careful tracking of the pollutants removed from the used lubricants, many of these small operations were forced out of business by rising costs. Their simple systems for isolating and filtering sludges out of used lubricants were no longer adequate, and they were unable to meet the increasingly stringent specifications for lubricants. Because of these failures, the army, navy, and air force in the mid-1960s ceased purchasing petroleum products containing recycled materials. While the military is not a huge consumer of lubricants, most state and municipal agencies and large private purchasers—such as companies buying for automobile fleets—choose products on the basis of military specifications. Furthermore, Congress also acted to require all lubricants containing even a small amount of recycled material to be labeled "made from previously used oil," implying inferior quality.

The industry suffered a further setback at the same time when the tax advantage that it had enjoyed during and after World War II was removed. Recycled lubricants had been exempt from the excise tax on lubricants made from crude oil, on the theory that recycled material had already been taxed. With this exemption eliminated, the price of recycled oil increased. For all these reasons, a heavy shadow has fallen over the entire industry.



More than 1 billion gallons of used lubricants are generated in the U.S. annually (left). By far the most common abusers of this resource are the many U.S. car owners who change their own lubricating oil (right).

Pollution by Just About Everything

Used lubricants collected from automobile service stations, fleet maintenance facilities, military installations, and industrial plants now contain a wide range of materials—the original detergents and dilutants, unburned fuel constituents, metal particles from the surfaces being lubricated, and combustion by-products. Though the use of leaded gasoline is decreasing, lead is still typically present in used oil in quantities of several hundred parts per million. The additives include highly refined, petroleum-based specialty chemicals that assure good flow, metal deactivators that prevent reactions between the lubricant and engine parts, lead scavengers that prevent lead buildup, and anti-oxidants to prevent the lubricant from breaking down at high operating temperatures.

Modern refining operations can easily deal with all these materials using little if any exotic technology. But difficulties often arise because unethical producers of hazardous wastes "hide" them in used oil to avoid the costs of proper disposal When generators of used oil must pay a minimum of $1 per gallon to dispose of liquid hazardous wastes while recyclers are paying up to $.50 a gallon for used oil, the temptation is hard to resist.

The most familiar example of this kind of pollution is the case of Times Beach, Mo., a town that the Environmental Protection Agency (EPA) evacuated and bought after used oil contaminated with dioxin was spread on roads and in horse corrals to control dust. Yet while PCBs and dioxins have received much of the publicity as pollutants in waste oil, toxic industrial solvents such as ethylene chlorides are much more common contaminants.

In another case cited by the EPA, waste oil from the Bridgeport (N.J.) Rental and Oil Services Co., stored in an unlined lagoon prior to treatment and recycling, was found to contain benzene, vinyl chloride, toluene, and other organics. These have contaminated nearby groundwater used as a human drinking source. The B and L Oil Co. in Newark, N.J., and its president have been convicted of selling for fuel waste oil containing phenolic compounds and chlorinated and aromatic hydrocarbons.

No exotic technology is required to treat modern uncontaminated oils for reuse as lubricants. The usual treatment consists of three stages of distillation—the first to remove water, the second (at a higher temperature) to remove light hydrocarbons (fuel), and the third (at a still higher temperature and high vacuum) to separate the lubricant from heavy-oil contaminants. A final step removes coloring and odor-causing components, by either catalytic action or filtering. In general, all these steps can be done using relatively low temperatures and pressures. They yield a product that is essentially as good as the virgin lubricants from new crude oil and that therefore sells in today's marketplace at only a small discount below the price of new oil.

The water removed from waste oil usually requires minimal treatment to remove hydrocarbons before disposal, while the light hydrocarbons removed in the second stage of distillation can be used as fuel for the plant. The heavy materials from the third stage are often used as an asphalt extender; the asphalt binds in the metal pollutants so that leaching is not a concern. However, the other materials with which used oil is contaminated can present serious problems, and the management of re-refining operations also deserves more careful consideration than it has been given.

An example of the dangers: an inactive waste-oil processing facility in Palmer, Mass., contains several leaking dikes and containment tanks that threaten to pollute surface water, wetlands, and groundwater. Indeed, sludge pits remain in many parts of the country as artifacts of the numerous bankrupt recycling plants of the 1960s.

The Long Wait for EPA

Waste oil was one of the targets when Congress enacted the landmark Resource Conservation and Recovery Act of 1976 (RCRA), legislation that has dramatically changed the way all hazardous wastes are handled. Indeed, RCRA singled out used oil for special attention: the EPA was specifically directed

DIAGRAM: OMNIGRAPHICS

The EPA's proposed standards for used oil burned as fuel could dramatically affect the recycling industry.

to write regulations for managing these materials. But despite this encouragement, the hazardous nature of waste oil, the known abuses in its management, and the ease with which it can be re-refined, EPA has been slow to meet Congress's mandate for devising regulations on collecting, reprocessing, and distributing used oil. Indeed, in 1980, four years after passing RCRA, Congress grew impatient and took matters into its own hands by passing a Used Oil Recycling Act. This removed the requirement that re-refined oil be labeled as such, urged EPA to write the mandated regulations on used oil, and provided money to states to educate businesses and individuals about recycling waste hydrocarbons.

Soon after the labeling requirement was lifted, the military allowed its branches to buy recycled oil. While the Reagan administration prevented EPA from spending the funds for education, the act publicized the fact that lubricants re-refined by current technology can be of high quality. Congress had finally adopted the rational approach of evaluating products on the basis of their performance rather than their origin.

Meanwhile, early this year, after nearly a decade, the EPA finally issued for comment proposed regulations covering the burning of used oils in nonindustrial boilers. These draft regulations propose limits for various pollutants in any commercial oil—for example, in the case of lead, somewhere between 10 and 100 parts per million (ppm). Used oil could be blended with virgin fuel to meet these specifications, except in the case of chlorine. But the crucial question of how EPA will enforce these regulations remains unanswered.

Much used oil now offered for sale contains several times the proposed limits on pollutants, so the regulations could dramatically affect this industry and probably reduce the quantity of used oil that could be burned as fuel. An EPA contractor has identified up to 1,000 used-oil collectors and several hundred reprocessors who are now selling some 600 million gallons a year of used oil as fuel. If the new regulations force many of these companies out of business, the rule making could dramatically increase the amount of used oil that must be discarded.

This fall, EPA is expected to announce a parallel set of proposed rules covering used oils sold for combustion in industrial boilers. Meanwhile, the State of New York, impatient with EPA, has set limits on pollutants in used oil for all types of boilers. Since no provision was made for phasing in these new standards, many waste oil distributors have been forced to curtail their operations and disposal problems have at least temporarily been made worse.

Three stages of distillation are typically used to process recycled lubricants. The water removed in the first stage usually requires minimal treatment before disposal, while the light hydrocarbons from the second stage can be burned to fuel the reprocessing plant. The final stage entails either a catalytic treatment with hydrogen or clay filtering. The former, more expensive to install, has the advantage of producing no or few hazardous wastes, while the filtering process leaves an oily clay that must be disposed of.

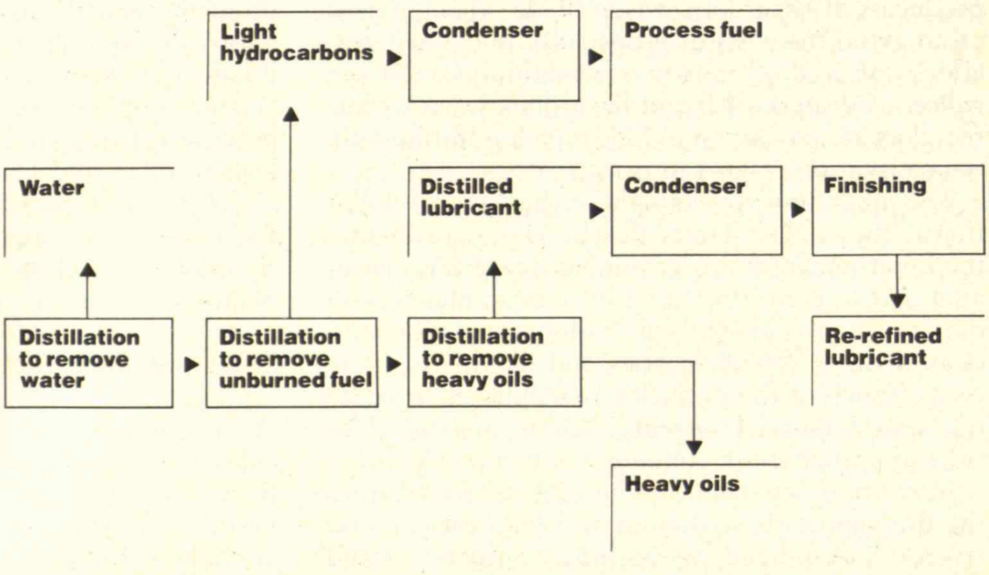
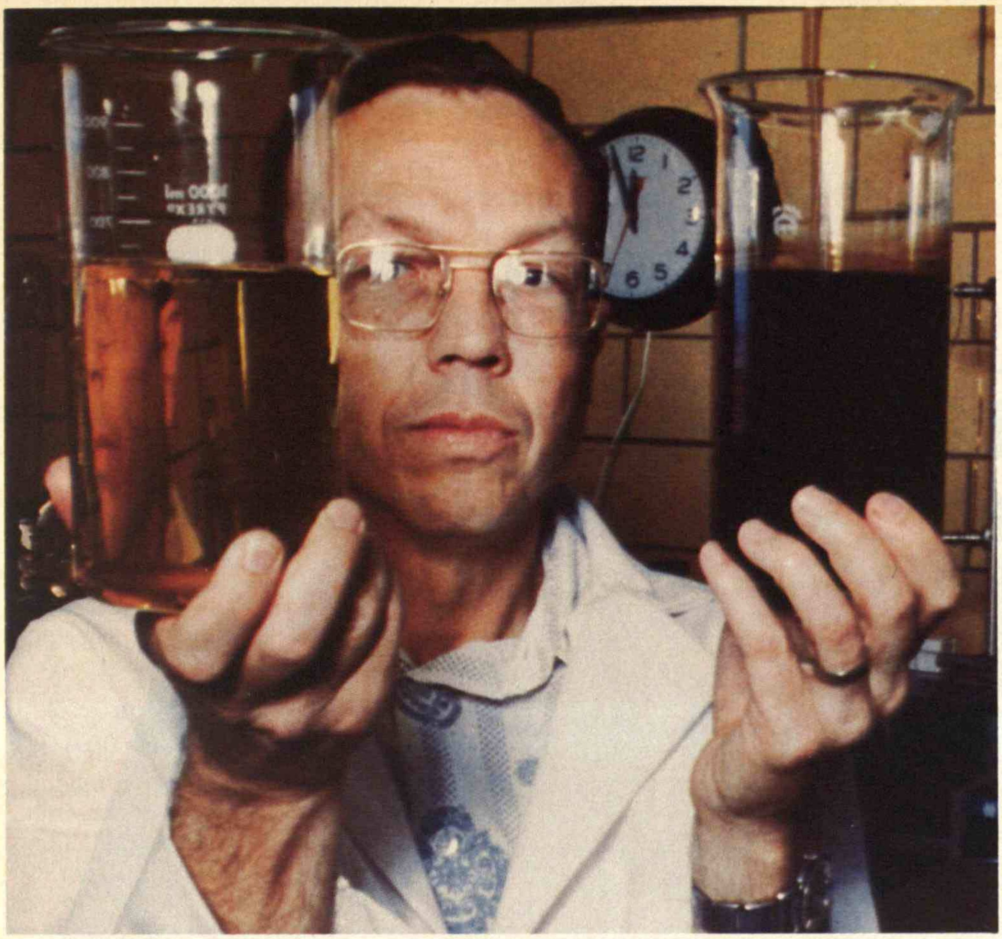


 DIAGRAM: OMNIGRAPHICS



As new additives made lubricants more difficult to decontaminate and reclaim in the 1960s, a large number of "ma and pa" recycling operations were forced out of business. But even with today's complex formulas, no exotic technology is required to refine used lubricants (right) into products that are essentially as good as virgin materials.

EPA is beginning to draft the standards it will impose on re-refined lubricants and the regulations that will apply to the industry that produces them. One possibility to at once stimulate the re-refining industry and improve its product is known to be under discussion: a requirement that all lubricants supplied to the federal government contain a specified small percentage of re-refined material.

A more important decision also remains to be made: whether formally to declare used oils a hazardous waste. Several of the largest states have already made this move and are regulating used oil as they do other toxic wastes. In January 1981, just before the Reagan administration moved into the White House, EPA proposed such a designation for used oil, but that proposal was withdrawn in the interest of reducing the regulatory impact of government. A possible compromise between the present lack of regulation and the high costs imposed on re-refiners by hazardous waste regulations is to declare used oil a hazardous waste unless it is in the hands of a licensed re-refiner or transporter.

Wanted: Far-Sighted Investors

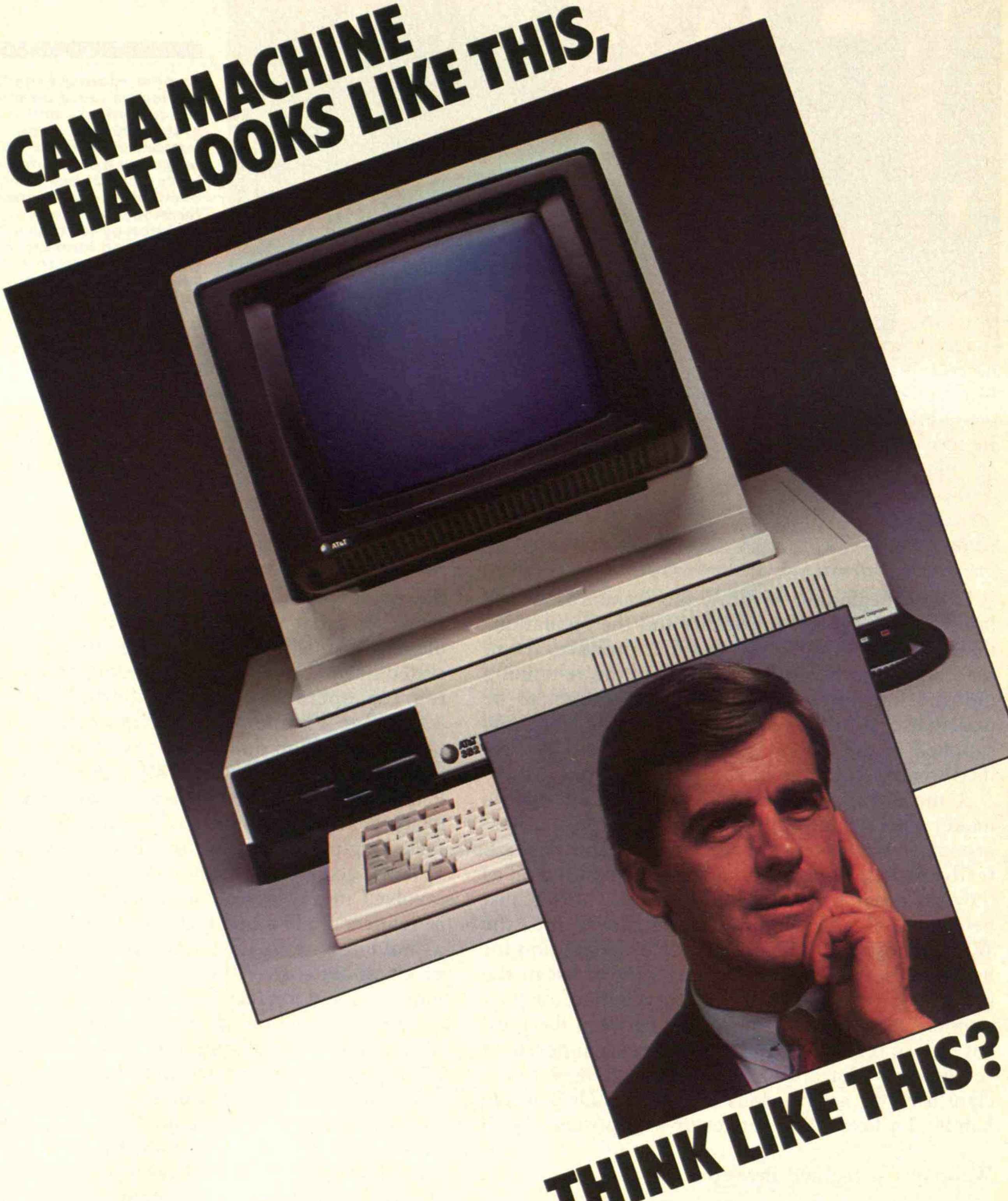
The three stages of distillation can yield re-refined lubricants that meet any standards the EPA is likely to set, and the technology is available to dispose of the waste products that result from the process. However, today's recyclers have the capacity to handle only a small fraction of the used lubricants generated in the United States. Building an efficient re-refining operation with a monthly capacity of 800,000 to 1 million gallons requires an investment of several million dollars. The used oil to feed such a plant might cost $12.50 per barrel on today's market, with the re-refined product selling at $50—suggesting at best a minimal annual return after deducting processing and handling costs.

Thus, economics do not at present favor those involved in any aspect of used-oil recycling. Most re-refiners are in a break-even economic situation—a "holding pattern" awaiting a time when petroleum products are scarcer, prices are higher, and there is more demand for recycled materials. Under current conditions, potential investors in the re-refining industry must take a long-term view, assuming that today's excess oil supplies and low prices will eventually be replaced by scarcity and higher prices. Those with re-refining facilities in place, experience in the business, and an established supply of used oil will then be in a position to take advantage of the increasing demand for quality lubricants.

But even such far-sighted investors may be reluctant to fund new plants until EPA completes the long

Continued on page 70

PHOTO: COURTESY OF DENNIS BRINKMAN


CAN A MACHINE
THAT LOOKS LIKE THIS,
THINK LIKE THIS?

Helping Paraplegics Walk: Looking Beyond the Media Blitz

BY HOWARD JAY CHIZECK

IT happens at least 20 times a day, 8,000 times a year: someone in the United States, usually young and healthy, suffers a spinal-cord injury and becomes partially paralyzed. When the injured patients ask their physicians, "Will I ever walk again?" the answer is usually "no." Some have to be told that they will never again feed themselves or brush their hair. The number of Americans with spinal-cord injuries that cause some form of paralysis is estimated to be between 175,000 and 500,000. Such injuries are almost surely permanent. The spinal cord simply does not heal itself, and to the victims, these injuries are a crushing blow. Their independence, their source of livelihood, and often their self-image have been suddenly and permanently damaged. The lifestyles of their families must change as well.

Historically, there have always been those who offered hope and "cures" for spinal-cord injuries—using devices chemical, mechanical, electrical, and spiritual. Testimonials of cures abound, primarily because the terms "paraplegia" and "quadriplegia" loosely describe a number of different conditions. People who are described as paralyzed may have partial control of their limbs; the spinal-cord nerves feeding those limbs may not have been completely destroyed. In some of these cases, physical therapy may restore the use of the injured limbs. In other cases, patients improve on their own.

In the last two decades, researchers have begun to stimulate paralyzed limbs electrically in an effort to restore function to paralyzed muscles. At least 12 research centers worldwide are investigating ways to apply, control, and coordinate such electrical stimulation, which is called functional neuromuscular stimulation (FNS). The results so far are promising: these experimental techniques have enabled a small, carefully selected group of paraplegic patients to walk hundreds of meters in the laboratory, using walkers for support. Some of these patients have walked tens of meters with crutches, which afford a greater measure of independence. An even smaller number have climbed up and down stairs equipped with hand railings.

In other labs, a small number of quadriplegics, paralyzed from the neck and shoulders down, have attained enough control of their paralyzed hands and forearms to accomplish simple but important tasks, such as feeding themselves, combing their hair, and brushing their teeth. These achievements could mean the difference between total dependence on other people and some sense of self-sufficiency.

For both quadriplegics and paraplegics, devices that can restore function in paralyzed limbs promise a new and exciting measure of independence. However, these devices are still experimental. A long list of difficult technical problems remains to be solved before such devices can leave the laboratory for

Electronic devices have enabled a few paralyzed people to walk and use their hands. But contrary to reports in the popular press, these devices are years away from commercial use.

PHOTO: J. P. LAFFONT/SYGMA

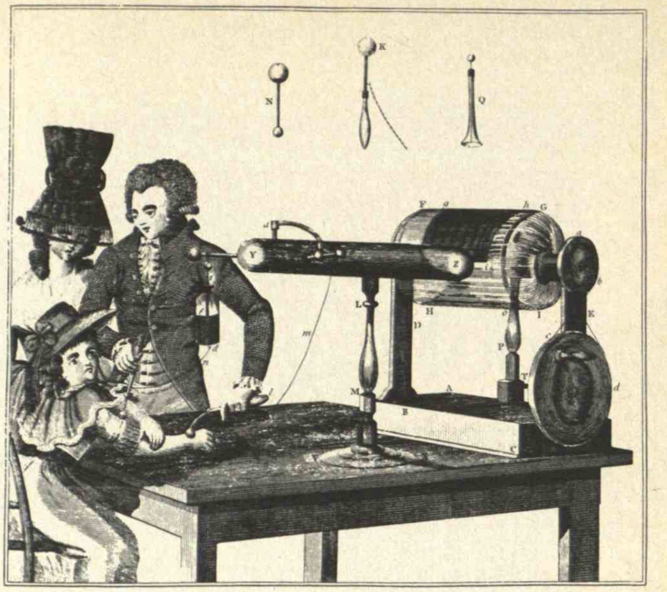
widespread use. Unfortunately, that is not the message that has been broadcast to the public through recent articles and television shows.

Articles such as "Someday I Will Walk Again" in *Reader's Digest* and "First Steps," a prime-time, made-for-TV movie on CBS, have exaggerated accounts of the capabilities and availability of FNS devices. Such accounts may have raised false hopes in many patients with spinal-cord injuries and their families. Investigators fear that these overblown media accounts will not only disappoint patients but impede future work in the field.

The truth is that no commercial FNS devices are now available that provide paraplegics with the ability to walk, or that enable quadriplegics to have hand and forearm control. Furthermore, such devices are not expected to be widely available in the near future.

The only commercial FNS devices now available are those that help correct relatively minor gait problems, such as lifting and dropping the foot at the right moment. Problems with foot drop usually occur when a patient is recovering from a stroke and only the lower leg remains paralyzed. The patient therefore has difficulty controlling the movement of that foot.

Having said all this, I must note that current progress in this field is very encouraging. While major advances are not on the immediate horizon, the future of FNS devices is bright.



Patients suffering from paralysis and convulsions were treated with electrical shocks as early as 46 A.D. Above: In the 1740s, scientists administered shocks from electricity generated by an electrostatic machine and stored in a Leyden jar. Benjamin Franklin reported cures using this technique.

Approximating Nature—Crudely

Before considering how these artificial devices work, we must first understand how the original equipment works. In all vertebrate animals, motion is accomplished when muscles contract. The muscles are turned on electrically by signals carried by nerves, which form the wiring of the motor-control system. Some nerves run from the spinal cord to the muscles, carrying signals that trigger movement. Most of these signals originate in the brain. Other nerves carry sensory information from the muscles, joints, and skin to the spinal cord and ultimately to the brain.

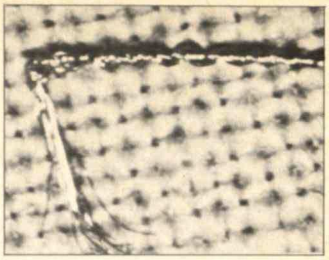
Sometimes the sensory information received at the spinal cord is enough to trigger the nerves that control movement. For instance, if you step on a piece of glass, the resulting sensation of pain triggers the nerves to command your foot to lift. This is called a reflex action because the information does not need to reach the brain to elicit a response.

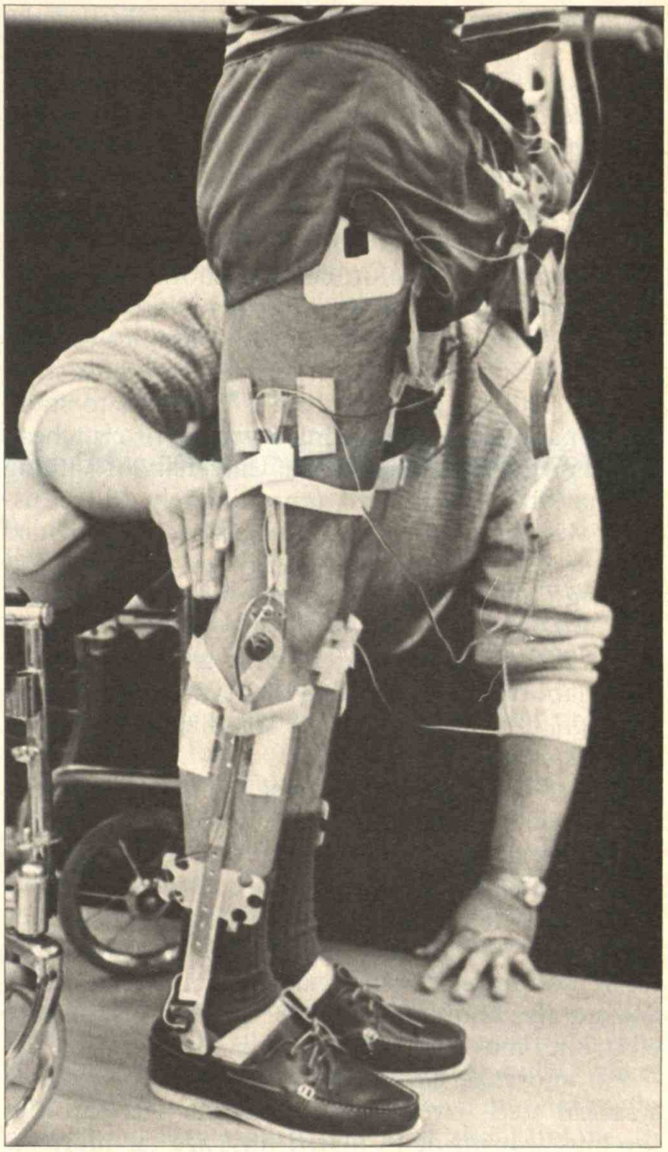
When the spinal cord is injured, motor-control signals from the brain to the muscles may be disconnected. As a result, the patient becomes unable to move certain muscles voluntarily. The higher the injury in the spinal cord, the more muscles will be paralyzed. While lower-level injury may result in paralysis of the legs, injury to the upper parts of the spinal cord may mean paralysis of the legs, trunk, and arms.

If the spinal cord is injured, the pathway for feeding sensory information to the brain may also be disconnected. As a result, the patient will have impaired (or no) sensation from the areas connected by nerves to the spinal cord below the injury level. However, reflexes will still exist.

The hope is to develop "neural prosthetic" devices that can at least partially replace the function of the injured spinal cord. The problem, however, is much more difficult than simply restoring signal transmission. Researchers must find some way of approximating the extraordinarily complex system for human motor control.

In this system, each single motor nerve cell (motor neuron) activates hundreds or thousands of muscle fibers. Fibers are the cells in muscles that, when activated by an electrical signal, essentially convert chemical energy that the body derives from food into contractive force. Each muscle fiber receives its stimulus from only one motor neuron. A motor neuron and all of its associated muscle fibers are together called a motor unit.





For movements such as walking or grasping an object with one hand, the central nervous system coordinates all the sensory information coming in with motor commands going out to the many muscles involved in producing the desired movement. In a sense, the human nervous system is an extremely complicated parallel processor, receiving, coordinating, and transmitting an enormous number of signals simultaneously.

At this stage, researchers are not even attempting to reproduce this natural motor-control system in its full complexity. Instead, they are concentrating on developing substitute systems that can achieve rudimentary motor control over paralyzed limbs.

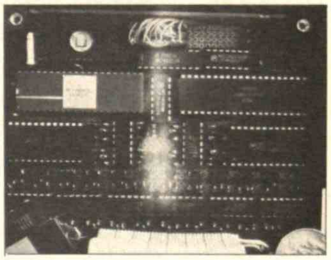
Benjamin Franklin and the Leyden Jar

The use of electrical stimulation for medical purposes has a long and somewhat dubious history. As early as 46 A.D., the Roman physician Scribonius Largus prescribed the use of the torpedo fish, an electric ray fish, to treat headaches and gout. The torpedo fish was to be placed over the painful spot, where it would deliver a numbing electrical shock.

Then, in the 1740s, when scientists first learned to produce electricity and store it (in a Leyden jar), electrical cures were reported for paralysis, kidney stones, epilepsy, and heart pain, as well as other ailments. Among the early practitioners of electrical stimulation was Benjamin Franklin, who used an electrostatic generator with Leyden-jar storage to treat patients suffering from convulsions, reportedly with good results.

The first use of electrical stimulation to contract muscles is commonly attributed to Luigi Galvani in 1791. Galvani produced the contractions by conducting electricity from a metal rod through the nerve and muscle of a frog's leg to another metal rod. Alessandro Volta verified Galvani's experimental results and corrected his idea that the source of electricity was the animal rather than the metal rods.

The modern use of electrical stimulation to activate paralyzed muscles is at least 25 years old. In 1960, Adrian Kantrowitz enabled a paraplegic to stand for several minutes by stimulating the muscles in his legs. The current, when switched on, created an electric field between a "ground" electrode and the active electrodes attached to the patient's skin. The electric field stimulated certain nerves in the patient's posterior that in turn caused muscles in the



Today electrodes almost as fine as human hair (magnified, top) carry the electrical signals that stimulate paralyzed limbs. The Teflon-coated electrodes are inserted with a hypodermic needle into the muscles that control movement. When these muscles are stimulated in sequence, the patient can stand or walk.

Center: Sensors taped to the legs send information on the changing angles of the joints to a portable stimulator/computer (bottom), which then sends the signals for the next move.

PHOTOS: HOWARD CHIZECK, CASE WESTERN RESERVE

body to contract. The contraction straightened the patient's knees, allowing him to support his own weight.

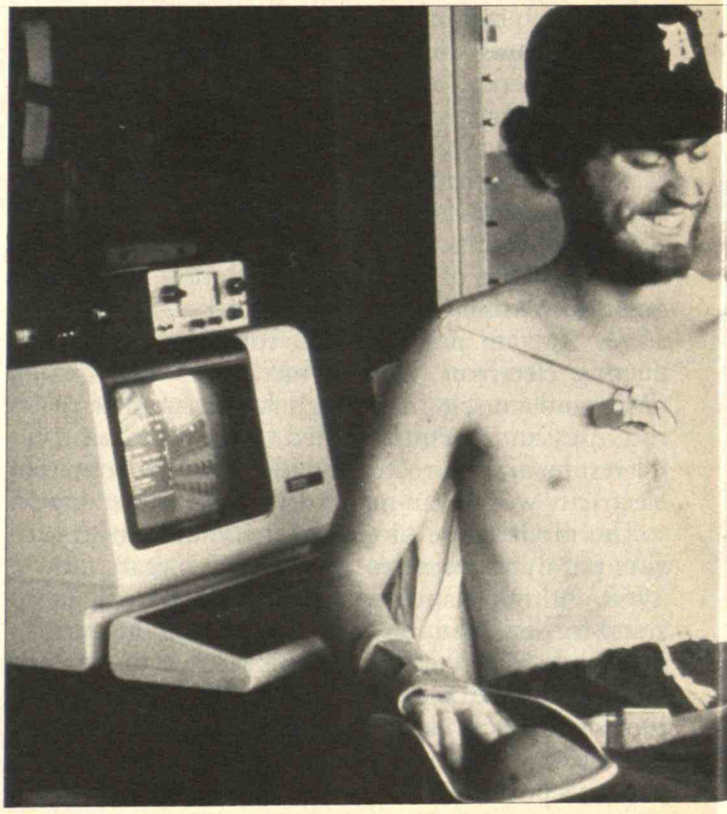
More recently, researchers have also developed techniques to deliver electrical stimulation through electrodes implanted in the target muscle, or surgically implanted around or on top of the actual nerves. In 1970, researchers at the Rancho Los Amigos Hospital in California, and another group in Ljubljana, Yugoslavia, were the first to report standing and some forward motion in paraplegics. The Yugoslavian group used surface electrodes for stimulation, and has since enabled 17 patients to stand and 3 patients to walk using a walker or crutches.

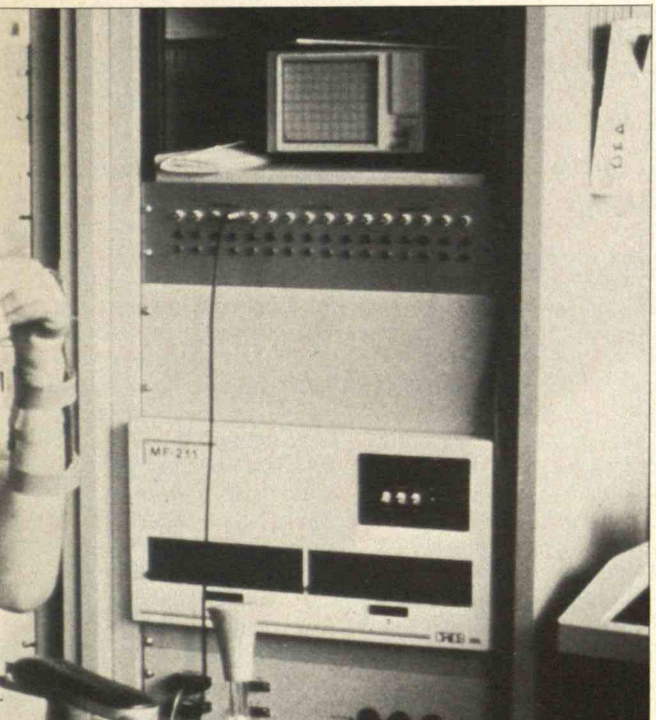
In 1973, a paraplegic at the University of Virgina at Charlottesville walked approximately 40 feet using a walker for support. Stimulation was provided by a system of implanted electrodes. In 1983, Dr. Herwig Thoma of the University of Vienna also used implanted electrodes to enable two patients to stand and walk up to 100 meters with crutches. Several other laboratories, including the Pritzker Institute in Chicago, are working on FNS standing and walking systems as well.

Researchers working on these systems face a number of technological problems. For instance, while surface electrodes are the easiest to install since they remain outside the body, they are not very selective in the muscles they activate. That's because they must send their signals though the skin and fatty tissue, so they end up activating a number of different muscles and nerves. Furthermore, most surface electrodes must be replaced daily.

Intramuscular electrodes, which contain insulated stainless steel wires inserted through the skin into the muscle with de-insulated tips, are far more selective and reliable. They usually stimulate only the particular muscle (and nerves) into which they have been inserted. However, even though intramuscular electrodes do not require surgery, they are difficult to install. Electrodes surgically implanted around or on top of specific nerves may turn out to be the best for long-term use. However, because they are installed through surgery, they are not the modus operandi for the temporary and often changing demands of research.

The size of the electrodes and the materials they consist of present further technological limitations. Smaller electrodes made of materials more like human tissue must be developed before large numbers





Devices that electrically stimulate paralyzed limbs promise a new measure of independence. Left: A paraplegic is able to stand and maintain his balance with the help of a neuromuscular-stimulation device developed at Case Western Reserve University and the Cleveland VA Medical Center. Researchers there have also devised a system of stimulation that enables quadriplegics—paralyzed from the neck down—to pick up a coffee cup (bottom).

of electrodes can be implanted inside the body. Even more constraining is scientists' lack of in-depth knowledge about the basic biomechanical workings of the human body. We simply don't yet know how to coordinate the transmission of signals to and from a large number of electrodes simultaneously. No more than 50 electrodes are now being used even in the most sophisticated experimental systems. The body's natural system of motor control, in contrast, employs thousands of simultaneous signals to regulate movement. Thus, today's artificial motor signals can command only large groups of motor units instead of individual units.

Stimulating Muscles by Trial and Error

All existing neural prostheses work in similar ways. First, the patient generates commands either by making a physical movement or by turning a switch off or on. In some experimental systems, quadriplegics move their shoulder a certain way and a transducer mounted on the shoulder translates that movement into an electrical signal. This signal then prompts muscles in the hand to contract a certain way. If the person pulls his shoulder back, for instance, his finger and thumb open and extend. In this way, a sequence of different shoulder movements can enable a quadriplegic to grasp and pick up a coffee cup.

In most experimental systems for paraplegics, the patient generates binary (on-off) signals using simple hand switches. The signals are sent to an electronic "stimulator," which uses this information to generate one electrical signal for each electrode. The electrodes carry these signals into the body, where they stimulate specific muscles. These muscles might control the way a particular joint should move, or how quickly the patient's foot should be lifted off the floor. When all these muscles are stimulated in the proper sequence, acts such as walking or grasping an object—which so many of us take for granted—can be achieved.

Researchers now use painstaking trial and error to determine the correct sequence of complicated movements needed for walking. These movements, which are different for every patient, can also be determined mathematically from knowledge of the biomechanical system. However, this approach is again constrained by our limited knowledge of the body's biomechanics. Once scientists establish the

Continued on page 62

The Nan Davis Story: A Trail of False Hopes

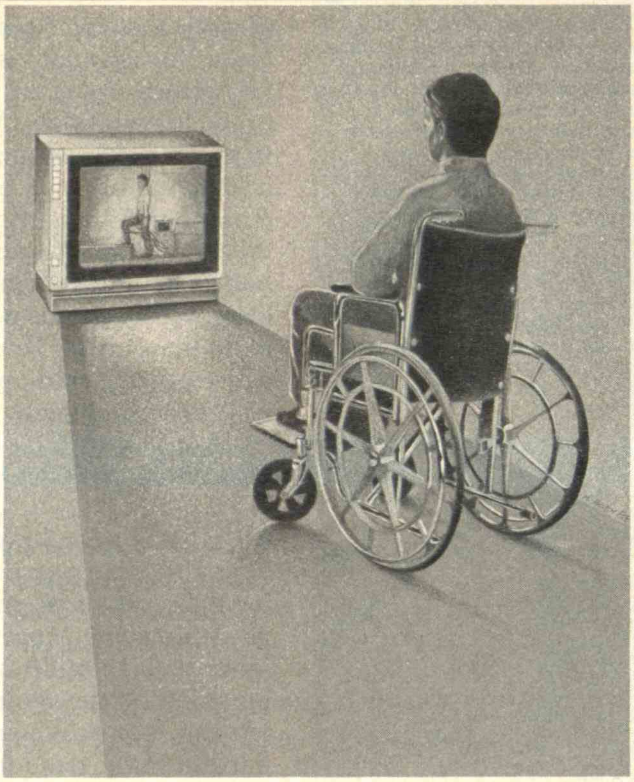
BY MICHAEL J. ROSEN

THIS spring, CBS aired a "real-life drama" based on the attempts of one paraplegic, Nan Davis, to walk. "First Steps" was a heart-rending, two-hour drama that culminated in the walk Davis (played by actress Amy Steel) took to receive her graduation diploma in 1983.

Nan Davis's story is far from unknown. In fact, "First Steps" was only the latest round in a flood of publicity that has surrounded her and the scientist whose work she is involved in—Jerrold Petrofsky, director of a center for rehabilitation engineering at Wright State University in Dayton, Ohio. Since 1982, Petrofsky's work in trying to restore function to paralyzed human limbs has been spotlighted in numerous newspaper articles and television shows, ranging from the *Wall Street Journal* and *People* magazine to "60 Minutes" and "That's Incredible."

So what? Why shouldn't Davis's story—an event with obvious human interest—be reported widely and dramatically? Why are more than two dozen biomedical researchers throughout the United States so concerned about this publicity that they have signed a public statement criticizing it? How do we know that the statement is not just sour grapes?

To appreciate the folly of permitting and even courting this sort of publicity, one must first look at what has been accomplished—and remains to be accomplished—in this field relative to what is being reported. For decades, researchers have been able to electrically stimulate paralyzed nerves and muscles, causing muscles to contract and produce movement in paralyzed limbs. When applied in a programmed sequence, such stimulation—known as functional neuromuscular stimulation (FNS)—is capable of producing movements that approximate the acts of standing, walking, and even grasping objects.



Misleading media coverage of one researcher's work has raised false hopes in many paralyzed patients.

The work now being done in research laboratories is strictly experimental, and profound technological problems remain to be solved. Most bioengineers believe it will be 10 to 20 years before FNS devices can help people with spinal-cord injuries achieve practical, independent walking—even with auxiliary support from crutches, canes, or walkers.

Furthermore, developing devices that help paraplegics walk *without* auxiliary support may take another two or three decades, if not longer. In fact, few experts have been bold enough to predict that a system with the basic capability of moving a leg to catch one's balance can be developed for practical use within their lifetime.

Did Nan Davis Really Walk?

Media coverage of FNS research has varied, of course, according to the style of the particular newspaper, magazine, or radio and TV show. One does not expect the same level of journalistic accuracy from *That's Incredible* as from the *Wall Street Journal.* However, almost all of the television coverage of Petrofsky's work has been misleading, and in some cases it has been downright wrong.

Even the NOVA episode entitled "Will I Walk Again?" was a cut below the coverage of science one expects from that public-television series. The show failed to provide balanced coverage of advanced research in laboratories other than Petrofsky's, and did not include critical commentary from knowledgeable scientists in the field. The show also included some completely erroneous statements. For instance, early in the show, the narrator, when talking about Nan Davis, says that "biomedical engineers and computer scientists are making the idea of the bionic woman a reality." Surely the producers of NOVA know that the word bionic implies replacing human limbs with artificial equipment, not restoring their natural function.

At another point, the narrator states that Petrofsky "was making an electronic nervous system." In fact, researchers are nowhere near approximating the incredible complexity of the human nervous system. What they are attempting to achieve is rudimentary control over a small number of muscles with an external system of electrical stimulation.

NOVA, the "60 Minutes" segments, and "First Steps" all conveyed the impression

ILLUSTRATION: A. HARDY ROBERTS

that only the fine-tuning of FNS devices remains to be accomplished before independent gait can be restored to paraplegics. The medium itself is partially at fault here. When television viewers see someone who was sitting in a wheelchair stand up and move her legs—no matter how crude the movement—they are left with the impression that the job of restoring gait is largely accomplished.

That strong visual effect could have been modified by the narrators, but those in NOVA and "60 Minutes" did little to contradict it. Both shows, in fact, used visual effects and voice-overs to reinforce the impression. In NOVA's first segment on Nan Davis, for instance, she is heard saying, "I always knew science would come up with a cure . . . and they're doing it now." The camera then zooms in on a scene with Davis pedaling an exercise bike; in the background, we see and hear a technician exclaim, "OK, we got it; it works!"

The overall impression is that Nan Davis is substantially closer to independent walking than she is to paralysis and mandatory wheelchair use. Unfortunately, that impression is false. As she walked to the podium in 1983, Davis was heavily supported by Petrofsky on one side and another Wright State professor on her other side. To move her legs, Davis relied on a computer-controlled FNS system devised by Petrofsky and operated by a wrist switch. Essentially, the switch signaled a portable computer, which instructed a stimulator to produce the pulses of electrical current that activated a few of the paralyzed muscles in each of her legs. The switch was operated by Petrofsky, even though he later was quoted by reporters as saying that Davis "ordered herself to walk . . . by pressing buttons on a wrist switch." Furthermore, an electrode on one of Davis's legs became dislodged during her walk, forcing Davis to support herself on only one leg.

In sum, Davis's trip to the podium that day did not come close to independent walking; she would have achieved a much greater degree of independence had she been in a wheelchair. The drama of the event has obscured the fact that Petrofsky succeeded only in demonstrating the severe limitations of current FNS technology.

One must wonder why Petrofsky has allowed his work to be the subject of such misleading publicity. Previous to 1982, Petrofsky had established a name for himself as a productive researcher in this field. Is it possible then that he does not recognize how much remains to be done to achieve walking through FNS? Does he recognize the false hopes likely to result and simply not care because publicity serves other needs? His repeated courting of media attention over a period of two years certainly makes it hard to see Petrofsky as a dupe of the press. It is difficult to understand his motivations in all of this.

Serious Disappointment

One thing, however, is certain: because of the publicity over his work, many victims of spinal-cord injury now believe they will soon be able to discard their wheelchairs. After the "60 Minutes" reports, for instance, Terry Hambrecht, director of the Neural Prosthesis Program and the National Institute of Neurological and Communicative Disorders (NINCD), says he received a "file of letters about two inches thick" from patients and their families seeking access to these miraculous new devices.

He and many other prominent scientists believe it is irresponsible to raise false hopes in paralyzed patients—or any patient, for that matter. In the recent public statement, at least 27 researchers nationwide expressed their concern that the "continuing dissemination of misinformation will cause serious disappointment to patients suffering from motor disorders and may reflect adversely on the significant contributions of the many responsible and productive researchers in this field."

The statement was prepared by Hambrecht and Gerald Loeb, a researcher at the NINCD, and signed by biomedical engineers at M.I.T., Case Western Reserve University, Pritzker Institute of Medical Engineering, and other established centers. It was printed in full as part of a lengthy article criticizing Petrofsky's work in the May 1985 issue of "The Institute," the newsletter of the Institute of Electrical and Electronics Engineers (IEEE).

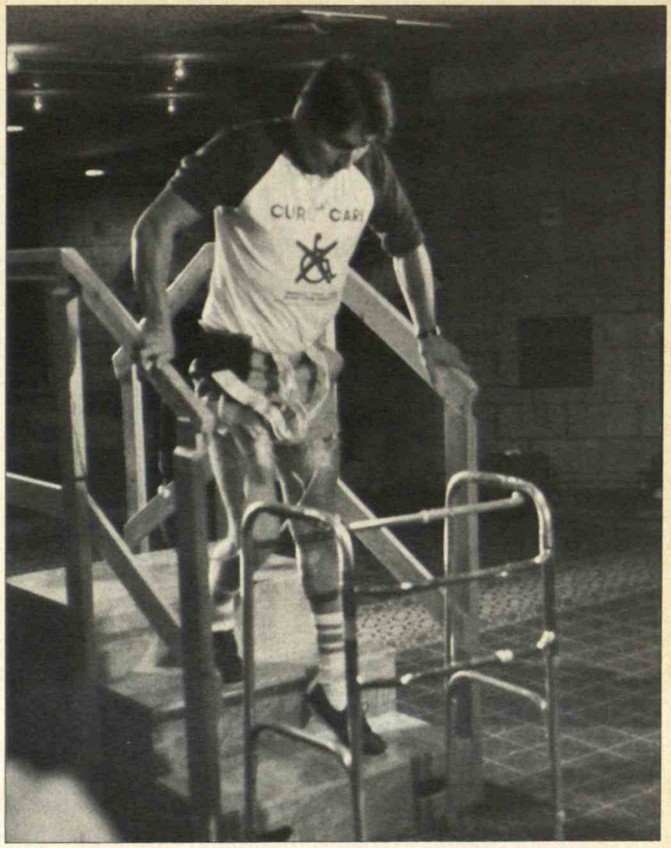
Another overwhelming impression that one gets from recent television coverage is that Petrofsky was the first to induce paraplegics to walk with FNS. In the NOVA segment, for instance, a news commentator covering Davis's walk is heard saying (with no qualification by the narrator), "The focus of the world was on 22-year-old Nan Davis, who became the first paraplegic in the world to walk under her own power. History was being made. For Nan and a few million other wheelchair-bound people in the world, these few steps represent the hope of normal walking some day in the near future."

The Real Pioneers

In fact, scientists successfully used electricity to stimulate paralyzed nerves and muscles a decade before Petrofsky's work hit the newsstands. At Rancho Los Amigos Hospital in California and at Edvard Kardelj University in Ljubljana, Yugoslavia, paraplegics were briefly on their feet in 1970. In 1973, a paraplegic at the University of Virginia at Charlottesville walked about 40 feet using a system of implanted electrodes with a walker for support.

The field of rehabilitation engineering can ill afford a reputation for premature or exaggerated claims of success. At stake is our credibility in the minds of colleagues, federal policymakers who fund our research, and, most importantly, disabled people whose needs we are attempting to address. If a backlash of criticism overtakes Petrofsky, it will probably not be any more accurate or focused than today's laudatory furor. Such a backlash could easily impede future research not only by Petrofsky but by all scientists in the field. The disservice to the disabled could extend further and last longer than anyone now imagines. □

MICHAEL J. ROSEN is principal research scientist in the Department of Mechanical Engineering at M.I.T. He is working on methods for managing muscle tremor and techniques for nonvocal communication—as well as FNS.



Continued from page 59

movement sequence, they must determine the series of electrical stimuli needed to produce that movement and store it in the computer, to be refined as the patient learns to make the desired movement.

In most of these systems, the electrical stimulator is driven by a nonportable minicomputer, but work is progressing on more portable units. One of the stimulators used for walking at Case Western Reserve can be mounted on the patient's belt. The battery-powered device has a sophisticated microprocessor programmed with a stimulation sequence custom-made for each patient.

This year some researchers have enabled paraplegics to walk much longer distances than ever before using more sophisticated control sequences. Under the direction of Byron Marsolais and colleagues at Case Western Reserve University, two patients at the Cleveland Veterans Administration Medical Center have been able to repeatedly move more than 400 feet using a rolling walker. One of these patients walked more than 700 feet. Using a stimulation sequence designed by Rudi Kobetic, this patient can also repeatedly ascend and descend stairs using hand railings.

In all these experimental systems, some method of support is needed to sustain the patients' weight and help them maintain their balance while they attempt to walk. The additional support can be provided by support harnesses, parallel bars, four-post walkers, rolling walkers, and crutches.

Fine-Tuning the Controls

A complicated sequence of signals must also be devised to restore function in the paralyzed hand muscles of quadriplegic patients. Hunter Peckham, Michael Keith, and colleagues at Case Western Reserve have developed a system that relies on subtle shoulder movements to direct basic grasping movements in the hand. More than 10 patients have learned to use this system for such tasks as eating, typing (with a mechanical aid for pushing the keys), writing, drinking from rigid cups, and holding cigarettes.

At present, most neural prostheses for paraplegics and quadriplegics rely on "open-loop control." The devices stimulate muscles based only on patients' commands and information previously stored in the computer. The controlling computer does not use measurements of movement to determine the stimulation signals.

In another, more sophisticated strategy, sensors taped or strapped onto the patient's limbs measure each limb's position and movements, and the computer uses this information to direct the stimulation of different muscles as needed. My colleagues and I at Case Western Reserve have developed such a system of "closed-loop control" in which four sensors measure the changing angle of the knees and ankles as our patients are standing. We have found that the system helps patients maintain their balance and perform other tasks without having to worry about whether their legs are about to buckle.

Jerrold Petrofsky at Wright State University has also reported using closed-loop control strategies for walking as well as for standing—work that has been well-publicized in the popular media. The publicity surrounding his work has been a source of controversy among other researchers (*see "The Nan Davis Story: A Trail of False Hopes," page 60*).

A system of closed-loop control does offer enormous potential for helping patients walk. Externally mounted sensors could be used to provide feedback from muscle movements as they happen and to time the next cycle of movements. For instance, information indicating that the right foot has reached the ground and is supporting weight might be used to initiate the next step with the left foot. Sensors may also eventually be used to measure and modify quantities of motion, such as the degree of force applied when the foot contacts the floor.

PHOTO: RUDI KOBETIC, CASE WESTERN RESERVE

One paraplegic at Case Western Reserve has learned how to ascend and descend stairs. He uses a portable microcomputer programmed with a sequence of electrical stimulation custom-made for him.

Several labs are also developing sensors to help quadriplegics regulate their hand motions when attempting to grasp a fork or coffee cup. However, no one has yet developed an effective closed-loop control system for accomplishing either walking or grasping an object. The problem is once again technological: external sensors are difficult to calibrate and to attach in a fixed position. These drawbacks could be dangerous if the error produces a misstep when the patient isn't ready to move. In addition, many patients find such visible electronic gadgetry unsightly. Developing suitable sensors is a major technical challenge in producing effective FNS systems for both paraplegics and quadriplegics.

Who Will Use Them and Who Will Pay?

Perfecting the devices now being studied in research laboratories for commercial use will take years. Today technicians must regularly adjust the neural prostheses used for walking. The devices also require a marathon-like effort from patients, since their muscles are easily fatigued from the constant artificial stimulation.

Most of the technological problems with neural prostheses will eventually be overcome. By the time they are, I hope we will have answered an often-neglected question: who will use these devices? This question really has two parts. Which patients, if given the choice, will use the systems, and which patients will be given the choice?

Despite the existence of walking aids such as long leg braces, most individuals who are paralyzed in both legs choose to use wheelchairs as their primary vehicle for mobility. This is simply because the physical effort associated with using braces does not justify the amount of increased access they afford.

Similarly, paraplegics will probably use FNS systems only if they are relatively easy to wear and take care of, and if they do not make excessive demands on patients' energy and time. How these prostheses look is also important; many paraplegics don't wish to wear a device that attracts unwanted attention.

Most importantly, neural prostheses must provide paraplegics with capabilities they don't now have. Such systems must provide them with the ability not only to walk reasonable distances but also to overcome barriers such as stairs. Devices that help paraplegics stand must allow them to do so while engaged in significant, mind-consuming tasks. If the new devices don't provide these added capabilities, it is unlikely that most paraplegics will abandon their wheelchairs.

Quadriplegics' acceptance of devices that help them use their hands may be a very different story. The ability to manipulate objects could mean the difference between dependence on nursing care and the ability to take control of many basic needs. There is also a strong financial reason for developing easy-to-use neural prostheses for quadriplegics. By replacing some of the nursing care quadriplegics require, such devices could save millions of dollars in health-care costs. These devices may even enable some quadriplegics to regain useful employment.

Although it is impossible to estimate accurately the cost of these devices, they will probably be at least as expensive as an automobile. Even so, given the strong financial incentives, public and private health-insurance companies will probably cover such devices, making them affordable to most quadriplegics.

The balance of costs and benefits may be less compelling for devices that aid paraplegics. Insurance companies might argue that paraplegics can already get around with wheelchairs, and many have jobs. The intangible improvements to individuals' quality of life are not always the overriding concern of health-care insurers. And with the growing push to contain medical costs, policymakers may decide that public health-care programs such as Medicaid and Medicare cannot afford to pay for these devices. Thus, when they finally become commercially available, not all paraplegics who need them may be able to afford them.

The future of efforts to restore muscle function to disabled individuals through the use of electrical stimulation is promising. However, multidisciplinary teams of scientists, engineers, and health-care professionals will have to work long and hard to solve difficult technical problems before these devices become widely available. This research should not be pressured by premature and exaggerated accounts of success in the popular press, which may raise false hopes among patients and damage the credibility of investigators in the field.

HOWARD JAY CHIZECK is assistant professor in the Systems and Biomedical Engineering Departments at Case Western Reserve University, Cleveland, Ohio. He is developing feedback control systems for upper- and lower-extremity prostheses.

The Bombarded Earth

BY EUGENE F. MALLOVE

POISED in the depths of space lurk deadly projectiles weighing millions of tons that will someday gouge the Earth. With roulette-like inevitability Earth's number will come up, as it has many times in the past, and the planet will once again collide with an asteroid. Were it not for the eroding effects of Earth's atmosphere and ocean, the asteroid-impact craters accumulated over the eons would be as prominent and numerous as those of the moon.

The most recent impact that left a visible crater occurred only about 50,000 years ago in what is now Arizona. Barringer Meteorite Crater near Winslow is over a kilometer in diameter and 200 meters deep, formed by an iron asteroid perhaps 35 meters across that struck with the energy of 200 bombs as powerful as the one dropped on Hiroshima. The bowl of Lake Bosumtwi in Ghana is perhaps the youngest asteroid crater larger than 10 kilometers in diameter. It is only 1.3 million years old, young enough to have impressed our forebears at its creation. Sudbury Basin in Ontario and Vredefort Dome in South Africa are among the largest asteroid craters, each more than 140 kilometers across.

Mounting scientific evidence ties the demise of the dinosaurs 65 million years ago to a collision between the Earth and a 10-kilometer body. Some theories even point to a cyclic pattern of mass extinctions of animal life on a planetary scale, caused by a swarm of comets that a mystery star dislodged from the cloud of comets surrounding the solar system. But not to worry: if the evidence is correct, the next cosmically triggered mass extinction is not due until 15 million years hence.

However, all has not been well for Earth even in our own time. For example, on the morning of June 30, 1908 a small asteroid or comet hurtled through the sky above the Stony Tunguska River in a remote area of Siberia. As it burned up in the atmosphere, it released explosive energy equivalent to a 12-megaton hydrogen bomb, destroying scores of square miles of forest. Only by chance was a more serious disaster avoided: the intruder could just as easily have hit Moscow or New York City. Thunderous blasts were heard 800 kilometers away, night skies all over Europe glowed eerily for days, and barographs in England detected a pressure wave that traveled around the world twice.

Eugene Shoemaker, a noted geologist and expert on asteroid impacts, has estimated from the number and ages of craters that there is a 12 to 40 percent chance that another Tunguska event will occur in the next 75 years. Other astronomers concur with these disturbing figures. A body with Tunguska's energy strikes Earth roughly every 300 years. Shoemaker, who is with the U.S. Geological Survey, further calculates that a 50-megaton wallop is likely to occur once every 1,200 years, and the 100,000-megaton impact of a one-kilometer asteroid could occur as frequently as four times per million years.

Much scientific attention has recently focused on the atmospheric effects of a nuclear war in which up to 10,000 megatons of nuclear explosives might be detonated. There is a developing consensus that the climate would change so dramatically that human survival would be jeopardized. So much dust and soot from fires would be thrown high into the stratosphere that it would block out sunlight for months. This would put much of Earth into such a deep freeze that life forms surviving the initial blasts would be extinguished. Shoemaker and others speculate that a large asteroid striking the Earth could kick up as much debris and lead to extinctions much like a "nuclear winter."

However, a major difference between the threat from asteroids and that from nuclear warfare is that asteroid impacts will *inevitably* occur unless action is taken to prevent them. The trajectories of heavenly bodies leave no room for obscure calculations regarding the balance of nuclear terror. Indeed, a blue-ribbon advisory group warned the National Aeronautics and Space Administration (NASA) in 1980 that "a large asteroid could someday destroy Earth civilization." The group continued: "In the 130 million years the dinosaurs roamed the Earth, they failed to develop the technology to avoid their own extinction. *Homo sapiens* has developed an adequate technology. He can avert any further extinction by asteroid impact. We think he should."

Yet the work of discovering and studying asteroids goes on with the usual shortage of funding for heavenly business. Shoemaker and astronomers Eleanor Helin and Carolyn Shoemaker started the

The human race may well be threatened by asteroids or comets that will strike the Earth. Can we detect these cosmic invaders? Can they be foiled?

EUGENE F. MALLOVE, until recently an astronautical engineer at M.I.T.'s Lincoln Laboratory, is now a science writer for the Voice of America. He received an S.B. and S.M. in aeronautical and astronautical engineering from M.I.T. and an Sc.D. from the Harvard School of Public Health.

Striking with the energy of 200 bombs as powerful as the one dropped on Hiroshima, an asteroid blasted this crater about 50,000 years ago in what is now Arizona. The Barringer Meteorite Crater, 200 meters deep and over one kilometer wide, is the planet's youngest major impact crater. Indeed, if the forces of erosion hadn't relentlessly erased signs of ancient asteroid collisions, the Earth would be as pockmarked as the moon.

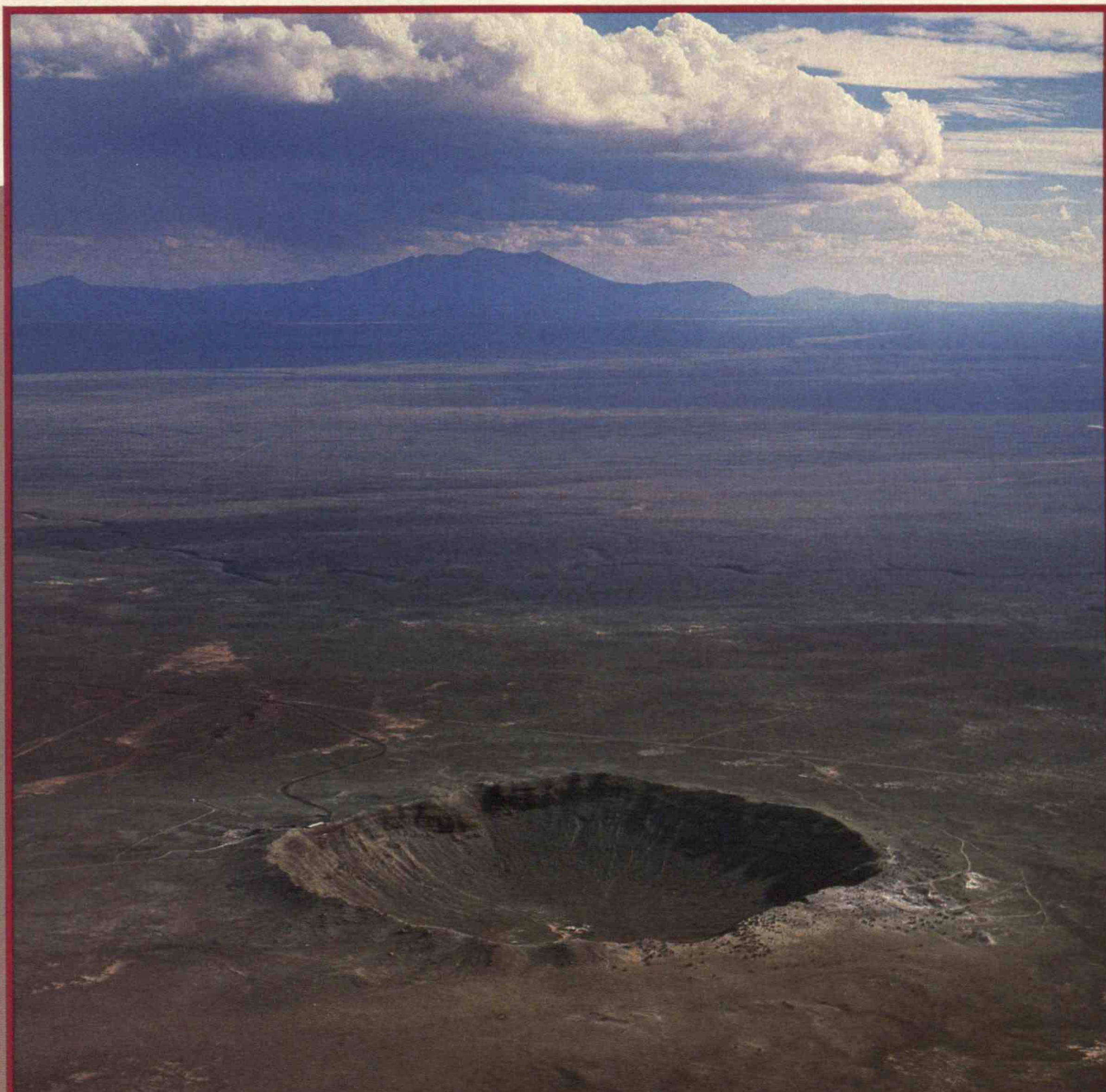
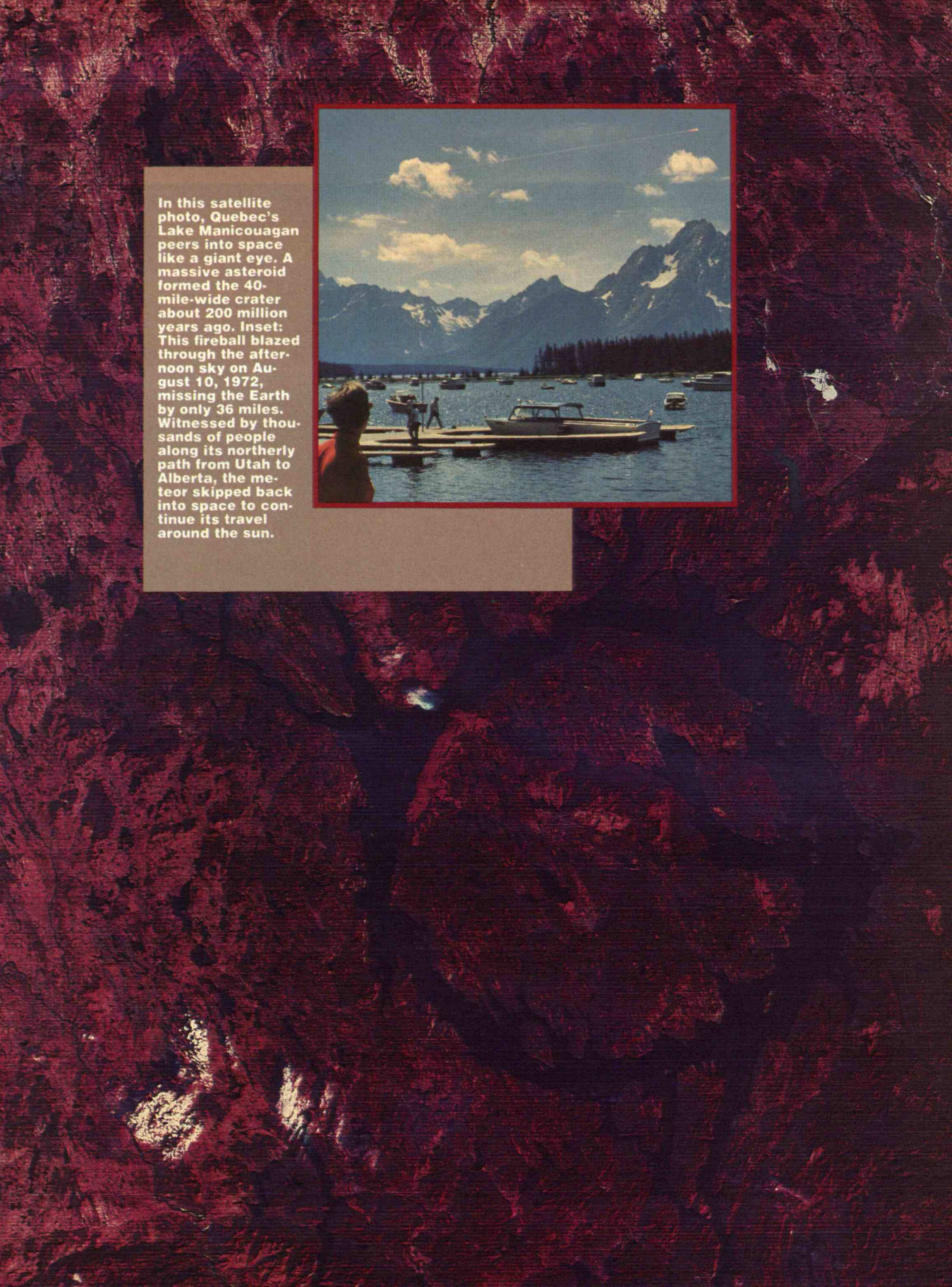
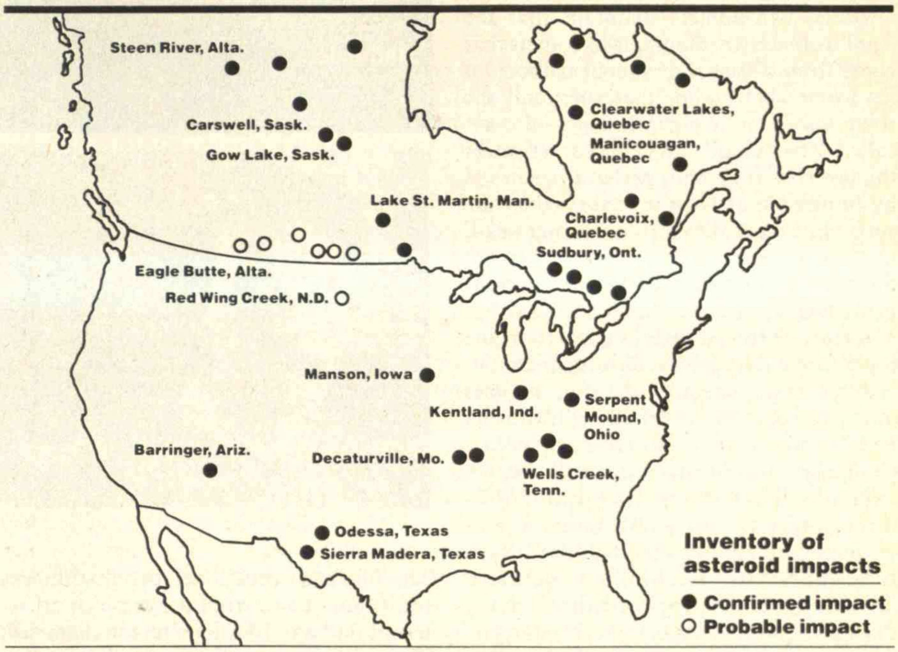


PHOTO: DAVID RODDY AND KARL ZELLER, U.S. GEOLOGICAL SURVEY



In this satellite photo, Quebec's Lake Manicouagan peers into space like a giant eye. A massive asteroid formed the 40-mile-wide crater about 200 million years ago. Inset: This fireball blazed through the afternoon sky on August 10, 1972, missing the Earth by only 36 miles. Witnessed by thousands of people along its northerly path from Utah to Alberta, the meteor skipped back into space to continue its travel around the sun.

Unlike nuclear warfare, asteroid impacts will inevitably occur unless action is taken to prevent them.



Planet-Crossing Asteroid Survey at the Palomar Observatory in 1973, using a photographic telescope known as a Schmidt camera. They photograph wide areas of the sky and try to pick out asteroid trails on the negatives. This and similar programs at other observatories have detected only a few asteroids per year. In all, about 60 asteroids have been spotted that will in time collide with the Earth or its moon, Mercury, Venus, or Mars. (Earth-crossing asteroids as a group have come to be known as "Apollos," named after one of the first to be discovered, by German astronomer Karl Reinmuth in 1932.)

Several new projects should help pick up the pace, however. Spacewatch, a projected ten-year effort to plot the courses of the estimated 1,000 asteroids larger than 300 meters in diameter that could strike the Earth, is led by University of Arizona astronomer Tom Gehrels. Rather than using photographic film, the so-called Spacewatch Camera will scan the skies with a sensitive electronic imaging device—a charge-coupled device, or CCD, in electronics parlance—that transforms the received view into electrical signals for computer processing. The computer will determine whether anything moves during repetitive scans of the same portion of the sky, thus discriminating a moving asteroid from background stars.

Spacewatch, which is funded by the Planetary Society and other private groups along with some NASA support, now uses a computerized telescope 36 inches in diameter at the University of Arizona's Steward Observatory on Kitt Peak. The fully automated camera will eventually be shifted to a new 72-inch-diameter telescope being installed, and Gehrels says his group hopes to increase the discovery rate to 10 to 100 asteroids per year when the project becomes operational in 1986.

Laurence Taff of M.I.T.'s Lincoln Laboratory also directs a NASA-funded program to detect Earth-crossing asteroids. The semiautomated system uses space-tracking telescopes located in New Mexico that were developed by the U.S. Air Force, which Taff has equipped with televison cameras sensitive to low levels of light. Taff exuberantly claims that his equipment is "about the best available for asteroid hunting," and says it will soon begin detecting Earth-crossers on a regular basis.

If astronomers did plot an asteroid's path accurately enough to show that it would likely strike the Earth in a matter of several years or months, what could be done to prevent catastrophe? A group of students and faculty in M.I.T.'s Aeronautics and Astronautics Department explored just such a scenario in 1967 in Project Icarus (*see page 69*). They presumed that Icarus would collide with Earth on June 19, 1968; in reality astronomers knew that the asteroid would miss by 6.5 million kilometers. The group concluded that exploding nuclear bombs on Icarus could nudge the kilometer-sized body from its usual orbit enough to miss the Earth.

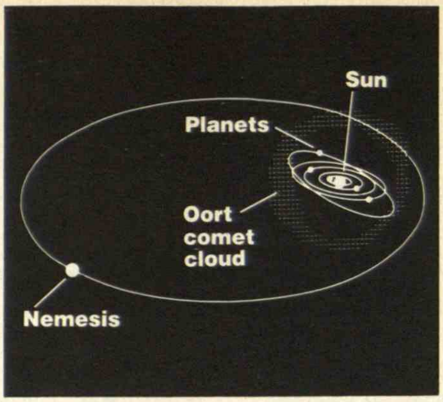
NASA has also considered the matter of planetary rescue, convening a conference in Snowmass, Colo., in 1981. The attending scientists concluded that, given accurate information on an asteroid's orbit perhaps 10 or more years in advance, a small conventional explosive, or even the thrust of a rocket engine, could change the asteroid's velocity enough to alter its path so that it would bypass Earth.

The history of speculation on diverting asteroids has yet another curious twist. In 1971 Samuel Herrick, an authority on celestial mechanics, proposed that a portion of Geographos be explosively cleaved and—with rocket propulsion—gently set on a course to strike Earth on August 25, 1994. The purpose: to strike northwestern Columbia at the Atrato River and form an interocean "crater-canal." The asteroid would also bring to Earth more than $900 billion worth of nickel and rare elements such as osmium, iridium, platinum, and gold. Herrick suggested that Geographos, if left alone, might cataclysmically strike the Earth by the year 2000 because of what he called the "ominous present orientation" of the asteroid's orbit. He made his proposals in a paper, published posthumously eight years later, that other scientists at the time judged "outrageously innovative" and "premature."

Astronomers calculate that about 15 new asteroids join the Apollo group each million years. But just where these Earth-crossers originate remains a contentious bone. Some astronomers maintain that they come from the asteroid belt located between the orbits of Mars and Jupiter. This region contains an estimated 10 billion fragments, ranging from 760-kilometer Ceres, the first and still largest asteroid discovered, to chunks a few meters in size. According to this theory, the gravitation of the huge planets Jupiter and Saturn "pumps" the orbits of some of the asteroids in the belt. Just as the repeated pushing of a swing acts in resonance to take it higher and higher, each gravitational pump disrupts the asteroid's orbit a bit more. Finally, the asteroid breaks away and begins its journey into the inner solar system.

PHOTOS: NASA; JAMES M. BAKER (INSET)

Nemesis, a possible companion star to the sun, may trigger mass extinctions by swooping through the "Oort cloud" surrounding the solar system and sending swarms of comets toward Earth (diagram). Richard Muller of UC-Berkeley helped originate the theory and is now searching for Nemesis.



Other astronomers maintain that the Apollo objects are remnants of comets that come from a vast reservoir of trillions of icy primordial bodies that surround the solar system in a gigantic halo—the so-called "Oort cloud." When a comet enters the inner solar system, perhaps perturbed by Jupiter's gravity, it is vaporized by the sun. The comet develops a blazing head, or "coma," and a tenuous tail of gas and dust. Scientists describe the tiny nucleus in a comet's head as a "dirty snowball"—a mixture of ices of various gases that glue together solid fragments of stony material.

After many passes by the sun, a comet may lose most of its volatile constituents and become a rocky asteroid. Some astronomers suggest that Comet Encke, for example, has reduced its fulminations through history and is now on its way to becoming an Apollo object. Indeed, Boston University astronomer Kenneth Brecher recently proposed that Encke, during its periodic journeys through the inner solar system, generated attendant swarms of large icy blocks. These blocks may have been the source of a Canterbury monk's observation in 1178 of "flames" on the moon, the Tunguska blast early this century, and the "moonquakes" detected by instruments left by the astronauts.

Death and Birth

Not only may wayward asteroids or comets spell destruction; growing evidence suggests that life on Earth in all its myriad forms may relate directly to such violent encounters. This theory spins out of observations made by Walter Alvarez, his father, Nobel laureate Luis Alvarez, and their colleagues at the University of California at Berkeley. In 1977 Walter Alvarez was studying rocks in Italy that contained a geological record of the critical boundary line between the end of the Cretaceous period some 65 million years ago, when the dinosaurs disappeared, and the following Tertiary period, when mammals began to diversify. The bottom, older layers of rock were rich in fossils. The upper layers were almost barren. And in between was a thin layer of clay presumably formed during the epochal transition period.

When Luis Alvarez analyzed samples of clay taken from the boundary layer, he found that it contained 30 times as much of the metallic element iridium as normal rocks do. Iridium is rare on Earth but thought to be more abundant in asteroids. The Alvarezes thus concluded that the extra iridium came from the crash of an asteroid perhaps 10 kilometers in diameter. They also suggested that the dust kicked up by the impact blocked the sun and doomed the dinosaurs along with nearly half of all life forms on Earth. A continuing stream of geologic evidence has since tied this Cretaceous-Tertiary extinction to asteroid impact, including almost indisputable evidence of shock impact in certain mineral crystals.

This theory took on new dimensions in 1983 when two University of Chicago paleontologists, David Raup and John Sepkoski, reported that mass extinctions over the past 250 million years seemed to have occurred at roughly 26- to 28-million-year intervals. Astronomers who had gingerly accepted the notion that an asteroid had caused the Cretaceous-Tertiary extinction were electrified, and rushed to publish theories using extraterrestrial causes to explain the apparent periodicity. While some of the theories are falling by the scientific wayside, one remains promising.

Richard Muller and Marc Davis of the University of California at Berkeley, along with Piet Hut of Princeton, proposed that a companion star to the sun could be the culprit. (Daniel Whitmire, of the University of Southwestern Louisiana, and Albert Jackson, of Computer Sciences Corp., have proposed a similar theory.) This stellar companion—perhaps a "red dwarf" with one-fifth the mass and one-thousandth the brillance of the sun—would travel in an enormous elliptical orbit, swooping every 26 to 28 million years through the Oort cloud of comets. The star's gravity would start millions of comets on a journey into the inner solar system, and several dozen large comets would likely embark on collision courses with Earth.

The companion star has not been discovered, and many scientists still have doubts about the theory. For example, some critics charge that any star orbiting at the proposed distance from the sun would have been stripped away long ago by the tug of other stars. However, Muller counters that the companion could have orbited much closer during the early days of the solar system, drifting slowly outward to its current location.

Muller and Walter Alvarez have buttressed their case by studying the ages of large impact craters that originated during a period of 250 million years. "If comets hit in storms," Muller says, "then there should be evidence of this in known impact craters on the Earth." To what Muller calls his "delight and amazement," the craters indeed formed on the same periodic schedule as the mass extinctions proposed by Raup and Sepkoski. So although this theory may yet turn out to be one of those blind alleys of science, it appears for now to be the best explanation for most of the data. As Muller wrote in a recent *New York Times Magazine* article: "The best evidence for the theory so far is simply the lack of other viable hypotheses consistent with everything we know about nature."

Of course, the ultimate proof of the theory will be discovery of the sun's mysterious companion. Muller and a team of astronomers and physicists are using an automated 30-inch telescope at Leuschner Observatory near Berkeley to study 5,000 red-dwarf stars visible from the Northern Hemisphere that they have identified in astronomical catalogs as candidates. They think the star is now about three light-years away. So far, the team has photographed nearly all the target stars once and is preparing to shoot them again in an attempt to detect some telltale movement. A confident Muller predicted recently: "If we are right about the nature of the star, we have about a 50 percent chance of discovering it in our Northern Hemisphere search." With luck, success could come within six months. Meanwhile, plans for looking in the southern sky, which will be harder because there is no catalog of stars to use as a reference, are also under way.

DIAGRAM: OMNIGRAPHICS; PHOTO: LIANE ENKELIS

Avoiding an Asteroid: When M.I.T. Took on Icarus

At 12:26 P.M. on June 19, 1968, the asteroid Icarus, which is nearly a mile in diameter, will crash into the mid-Atlantic, 2,000 miles east of Florida. Its impact—the equivalent of a 500,000-megaton bomb blast—will splash out some 1,000 cubic miles of seawater and form a crater 15 miles across in the ocean floor. Tidal waves 100 feet high will sweep across coastal cities on both sides of the ocean, and earthquakes 100 times worse than any ever recorded will be felt all over the world. Clearly, Icarus must be stopped. No expense will be spared, and the only limitation is time. The program must use existing space technology and hardware, and it must succeed.

THIS chilling pronouncement was delivered by M.I.T. Professor Paul Sandorff, who presented it in the winter of 1967 as a hypothetical problem to his class in systems engineering. After 15 weeks of frantic planning, 21 senior and graduate engineering students worked out a complex scheme that they—and their instructor—believe would save the world from collision with an onrushing asteroid.

Icarus itself is quite real. Unlike most asteroids, which circle the sun in a belt between Mars and Jupiter, Icarus has a highly elliptical orbit. In its journey, it moves close to the Earth's orbital path every 13 months and narrowly—by astronomical standards—misses the Earth once every 19 years. Astronomers have charted its current orbit precisely, and predict that it will pass within 4 million miles of the Earth in June 1968. But they also know that the gravitational pull of the Earth and other planets will gradually change the asteroid's orbit and could some day place it on a collision course with the Earth.

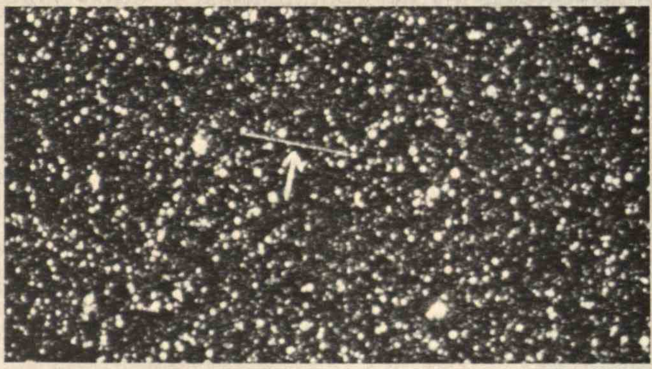
Assuming that such a disaster was nearly upon them, the M.I.T. students organized themselves into seven specialized groups to study the trajectories necessary to intercept Icarus, the space hardware and communications equipment that was available or could be quickly produced, and the feasibility of using nuclear explosions for the task. The groups then coordinated their findings and, using systems engineering, devised a master plan to meet the threat of Icarus.

Saving the Earth, they decided, would require launching a salvo of hydrogen bombs into the asteroid's path. To loft the warheads, the United States could rush to complete five *Saturn 5* Apollo rockets now under construction and build four more from scratch. A second Saturn launchpad now under construction at Cape Kennedy could be completed and a third built. The Atomic Energy Commission would be requested to assemble six 100-megaton H-bomb warheads—the minimum size necessary to attack Icarus effectively.

On April 7, 1968, after three shots to test the performance of the bomb-carrying spacecraft, crews would launch the first vehicle toward Icarus, still 100 million miles away. Guided by radar signals bounced off the asteroid from Earth and picked up by on-board receivers, the warhead would approach the asteroid on June 6, pass to one side, and explode only 100 feet away. If all went well, the blast would deflect Icarus enough to make it miss the Earth or perhaps disintegrate it.

Should the first shot miss its mark or otherwise fail, the five remaining missiles would provide insurance. If an early shot broke the asteroid into pieces still large enough to menace the Earth, for example, later vehicles could be used to pulverize them. The final shot, if needed, would be launched on June 14 and intercept Icarus just 1,200,00 miles away, barely 18 hours before its rendezvous with the Earth. □

Adapted from an article in Time *magazine, June 16, 1967.*



Astronomer Walter Baade discovered Icarus, an asteroid that passes near the Earth every 19 years, in this 1949 time-elapsed photograph.

Muller and his colleagues have christened the hypothetical star Nemesis, after the Greek goddess who punished the excessively proud and powerful—the dinosaurs, in Muller's image. (And us?) But other scientists have suggested the name Shiva, after the Hindu god of destruction *and* reproduction. It is clear that if extraterrestrial bodies have caused periodic extinctions, then the course of evolution owes a lot to the "death star." Mass extinctions, say some scientists, would provide ecological breathing room for new species to emerge and flourish.

Those who study asteroids, comets, and animal extinctions do not ordinarily make headlines. Their work in uncovering our intricate cosmic connection to the rest of the universe often goes unnoticed in the bustling world of politics of the moment. What perverse trait causes humans to spend billions on systems to deflect hostile projectiles that may never be dispatched, yet makes us oblivious to our tenuous dominion in the natural world? Right now, silent telescopes are gathering precious data as they hunt for celestial intruders. Will there be enough time to turn even a fraction of our arsenal toward defending the Earth? Or will there be a supreme irony: weapons of fraternal conflict developed over centuries will be useless to save us from celestial extermination. □

ILLUSTRATION: JON MCINTOSH; PHOTO: HARVARD UNIVERSITY PRESS

Profitability will be elusive for recyclers until today's oil glut is replaced by scarcity—and higher prices.

Continued from page 51

process of establishing the regulations under which re-refiners will operate. The regulations proposed so far seem to encourage re-refining of used oil over reprocessing it for fuel, but the final requirements are not yet clear. Only when the regulations are in place will rational decisions on the most attractive options be possible.

Even when the regulatory questions are finally answered, obtaining financing may not be easy. The process of planning and obtaining environmental permits for constructing a re-refining plant can be a long one, and at least a year will be required to build a re-refining plant even after obtaining permits and financing. Furthermore, almost all the used-oil recycling facilities built in the past decade were financed at least in part by federal low-interest loans. These incentives, provided under pollution-abatement and industrial-development programs, are being cut back or terminated.

Burning Lubricants as Fuel

Under present market conditions, it is often more economical to burn used oils than to restore them to meet the high specifications of modern lubricants. Used oils often have high heating values, and they can be added to low-grade virgin fuels to improve their flow and combustion. Or they can be burned directly; trucks picking up "waste" oil can sell the same material to nearby households and businesses as fuel.

Contaminated lubricants must be processed to make them usable as fuel, depending on the nature and concentration of the contaminants. If each truckload of waste oil requires laboratory analysis and possible special treatment, the cost rises rapidly. Indeed, under these conditions re-refining may be more economical than treatment for burning, since recycled lubricants command a significantly higher price than fuel.

The crystal ball for reusing lubricants as fuels is a cloudy one. While the prices of fuel should increase if oil supplies decrease, EPA restrictions on the contaminants in waste oil used for fuel are also increasing, so the cost to process used lubricants will rise.

A new plant to process 10 million gallons of oil a year for use as fuel under the proposed EPA specifications would probably cost $2 million. That compares with $8 million for a plant to re-refine a similar amount of oil for use as a lubricant. Currently, the profit from re-refined oil is not four times that from reprocessing. Whether the rise in fuel prices in a time of future scarcity will offset the increased fuel-processing costs under the new EPA rules is unclear.

These markets are governed by complex, interrelated economics. Recycled products normally sell at about 10 percent less than virgin products, even though most of the former meet or exceed the specifications for virgin products. The cost of used oil required as a feedstock and the selling prices of both re-refined lubricants and fuels are controlled by the prices of their virgin competitors. Thus, the recycler, whatever the final product, has little control over profitability except by reducing operating costs and devising advantageous waste-oil disposal contracts. In both these situations experience may be the greatest teacher.

Double Payoff

As in so many areas of waste management, European countries have been leaders in recycling lubricants, with the high cost of imported crude in Europe providing the impetus. The European approach has been to require all users—industry and individuals—to recycle all waste oils they generate. Virgin lubricating oils are taxed, and the resulting income is used to subsidize the recycling industry. As a result, many countries collect up to 65 percent of the available waste oil, with most earmarked for re-refining into lubricants. This system has worked so well in Germany that the tax on virgin lubricants has been eliminated; the recycling industry no longer needs to be subsidized.

Such an approach has not been politically acceptable in the United States, and—pending EPA's long-awaited initiatives—we continue our wasteful and dangerous practices in handling waste oil. However, there is light at the end of the tunnel. EPA should finalize its regulations on waste oil within the next two years, and once the regulatory machinery is in place, increased investment in this neglected technology can begin. Indeed, potential investors are already showing interest. Considering the impact on both energy supplies and the environment, it is a prospect with singularly high social returns.

DENNIS W BRINKMAN is a project leader in fuels and fuels technology at the National Institute for Petroleum and Energy Research in Bartlesville, Okla.

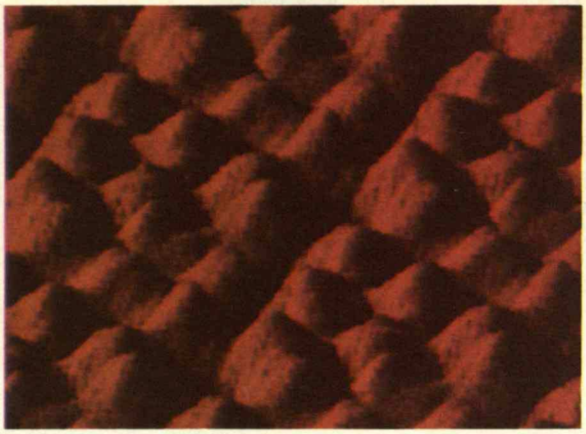


Figure 1. *This three-dimensional representation of a silicon surface was obtained by scanning tunneling microscopy, developed by IBM. The individual hills or bumps indicate actual atoms separated by as little as six angstroms. (One angstrom is one ten-billionth of a meter.)*

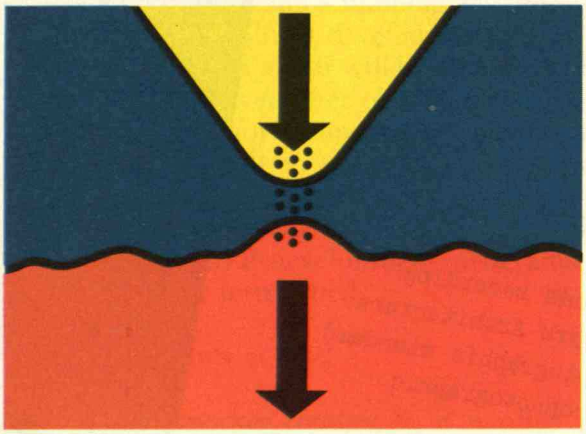


Figure 2. *IBM's new microscopy technique makes use of a phenomenon called vacuum tunneling, which involves the passage, or tunneling, of electrons between two conducting or semiconducting solids that are narrowly separated by a vacuum. Tunneling occurs because electrons have wavelike properties as well as particle properties. This means, according to quantum theory, that electrons appear as electron clouds that spill out slightly beyond the surfaces of the solids in which they originate. As a result, there is a finite probability that electrons will tunnel through the vacuum.*

Miniaturization is the driving force behind the computer revolution. As computer chips continue to evolve, their structural details are becoming so small that it is vital to understand them at the atomic level.

Recently, IBM researchers have succeeded in examining structures at the atomic level by developing an absolutely new kind of microscopy technique—scanning tunneling microscopy, or STM. Specifically, they have produced three-dimensional images of the surface topography of solids that show vertical position differences as small as 0.1 angstroms (one angstrom is one ten-billionth of a meter) and horizontal position differences as small as six angstroms. Such simultaneous resolution is unprecedented.

The new microscopy technique makes use of a quantum-mechanical phenomenon called vacuum tunneling, which involves the passage, or tunneling, of electrons between two conducting or semiconducting solids that are narrowly separated by an insulator or a vacuum.

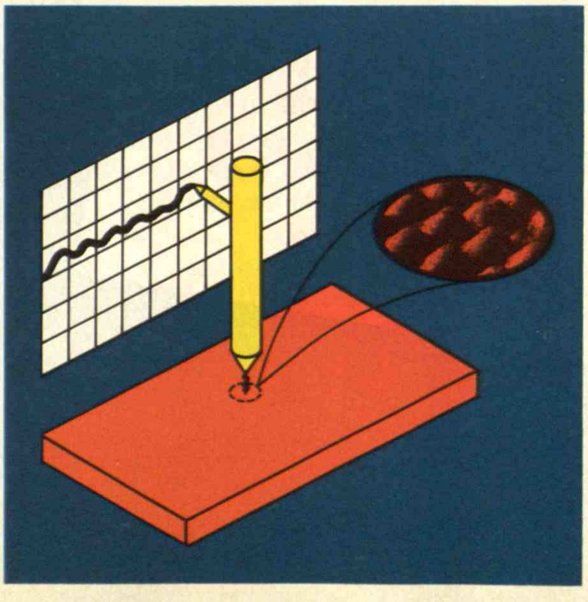


Figure 3. *The principle of the scanning tunneling microscope is quite simple. As a probe tip is scanned across a surface's microscopic hills and valleys, its vertical position is adjusted to maintain a constant tip-to-surface distance (by keeping tunnel current constant). The probe consequently follows the surface contour as it moves, so that monitoring its vertical position can be used to yield a two-dimensional representation of the surface contour for each scan. The full three-dimensional image is obtained by assembling an entire sequence of scans.*

Scanning Tunneling Microscopy

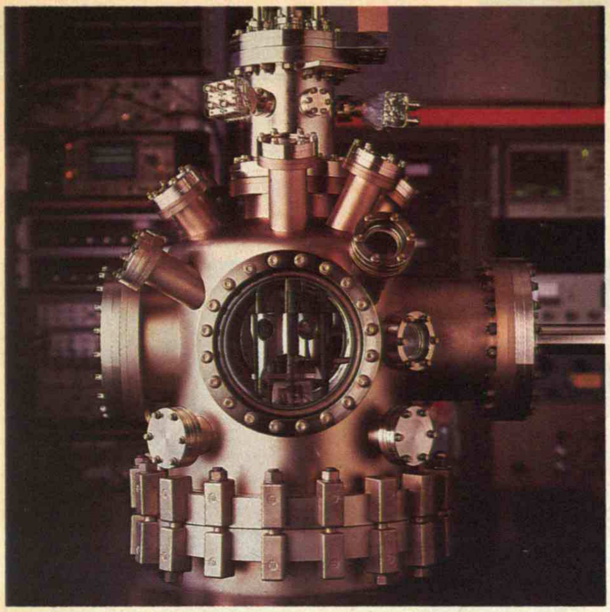


Figure 4. *The scanning tunneling microscope is contained inside this chamber. The electronics (background) collect and process the measurements and then display the results on a screen or plotter. An absolute necessity for making measurements is a vibration-free suspension, which also had to be specially developed by the IBM researchers.*

Tunneling through solid insulating barriers was first demonstrated in 1957; it was only early in 1982 that controlled vacuum tunneling was demonstrated by IBM in an experimental configuration suitable for microscopy.

In principle, the scanning tunneling microscope takes advantage of the strong dependence of the tunnel current on the separation between two solids. One solid has its surface under investigation; the other, a metal tip, is a probe electrode. As the probe moves laterally across the surface (while separated from it by about ten angstroms), the tunnel current will vary in accordance with changes in the tip-to-surface distance. The tunnel-current variation in effect is a measure of the surface topography.

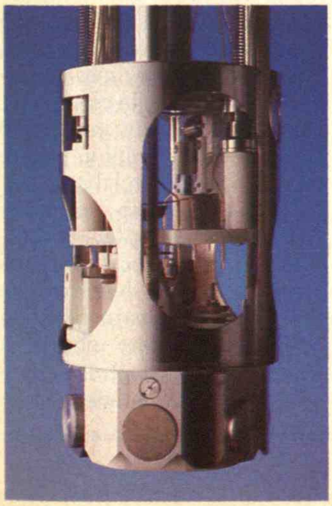
In practice, the vertical position of the probe is changed to keep the tunnel current, and thus the tip-to-surface distance, constant for all points. In that way, monitoring the position of the tip while scanning yields a topographic picture of the surface. The technique is so sensitive that a change in tip-to-surface distance by the diameter of a single atom produces a tunnel-current change by a factor of 1,000.

By providing a more detailed view of surface structures, STM has already significantly advanced the understanding of important materials such as silicon. However, STM is more than a surface structural tool with atomic resolution: it also images surface parameters (such as composition and oxidation state) and can determine electronic properties. This opens fascinating possibilities in many areas of science and technology.

STM can be performed at ambient pressure and can see surfaces covered by nonconducting liquids. The ability to operate under such conditions makes STM attractive in many different fields, from engineering to biology.

Scientists at the IBM Zurich Research Laboratory developed the world's first scanning tunneling microscope. Their contributions are only part of IBM's continuing commitment to research, development, and engineering.

For free additional information on STM, please write:
IBM Corporation, Dept. 1007,
P.O. Box 5089, Clifton, NJ 07015



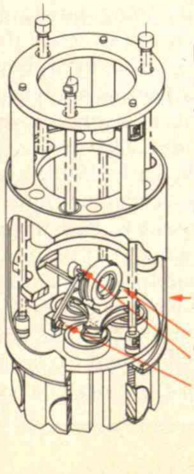
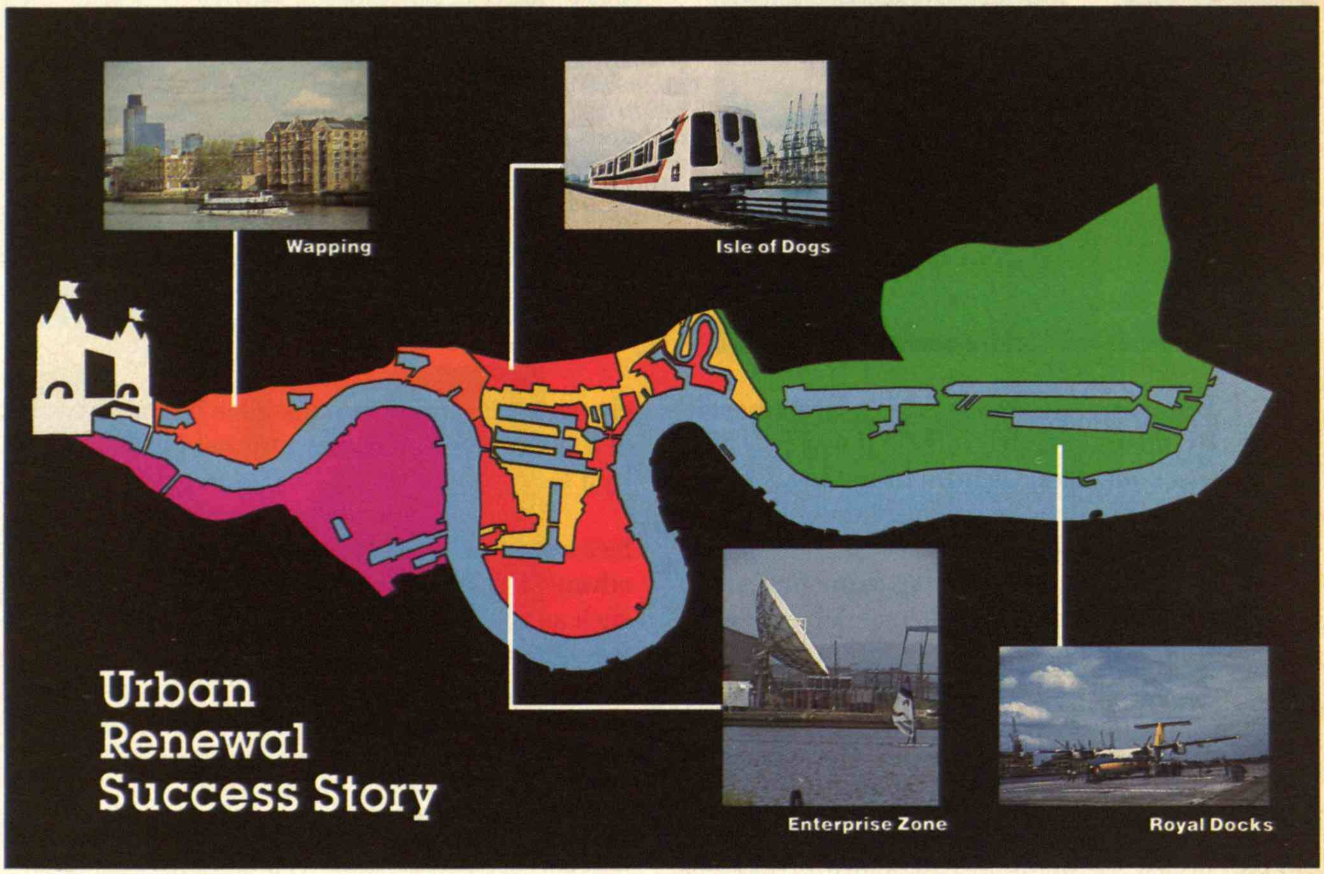


Figure 5. *Photograph and illustration of the scanning tunneling microscope. Note that the microscope is lowered into the chamber (shown in Figure 4) when in use.*



Urban Renewal Success Story

Until recently, most Londoners knew "docklands"—the land along the River Thames east of the Tower—as an area of derelict docks, empty warehouses, silent factories, and run-down tenements. But in less than four years, the London Docklands Development Corp. (LDDC) has changed this neglected area into an upscale address. Now a tidy red-brick road meanders through a sea of new construction, and completed buildings display sparkling glass faces and tight angles that suggest modern high-tech living. The LDDC, a public agency, does not build buildings but tries to entice private investors to do so. The agency claims that for each public pound spent, private investors have put five and half pounds into new and renovated housing, industrial and office space, and recreational facilities.

Boom to Bust

Bustling activity is not new to this area. Docklands was the nerve center of Britain's great trading empire during the 1800s, and by the 1930s, half a million people lived and worked at the docks and in related heavy industry. However, beginning in the early 1960s, huge modern cargo ships had trouble navigating the Thames, and shippers moved to new docks nearer the sea. Soon the docklands population had shrunk to 50,000, one in five workers was unemployed, 93 percent of the housing was publicly owned, and millions of square feet of industrial floorspace had been left to decay.

In 1981, Parliament formed the LDDC and gave it a budget, renewed annually, of around £55 million. That budget is relatively low for a major development effort, but the agency can reinvest income from land sales into other projects. The LDDC's planning power is complete: it can override the authority of the local boroughs and force landowners to sell. But its lasting power is limited: the LDDC will disband in the early 1990s and return any remaining money to the Treasury. Parliament also designated part of docklands an enterprise zone (EZ), in which investors pay no local taxes until 1992 and can write off all capital expenditures against corporate taxes. Partly because of such large tax breaks, putting up an office building in the area costs only one-fourth as much as in the City of London, the prestigious financial district two miles away.

Unique Potential

The LDDC has spent £86 million on buying and clearing land and putting in roads, sewers, and gas lines. In response, private investors have put £488 million into 4,500 homes and 5 million square feet of commercial and industrial floorspace. Four thousand people are employed in new local jobs, and another fifteen hundred are working on construction that will lead to more jobs. At a recent world congress of realtors, a London industrial real-

A public agency has transformed docklands, a long-neglected area along London's Thames River, into the focus of bustling economic activity—and some controversy from long-time residents.

In Wapping, Oliver's Wharf is being refurbished for residential and commercial use. A £77 million light-rail system based on the Isle of Dogs will connect docklands with London's Underground. On the Royal Docks, a STOLport—constructed for "short takeoff and landing planes"—will provide a direct link to Europe. And in the Enterprise Zone, major tax breaks and the area's lack of interference have convinced communications companies to set up shop.

tor called the LDDC's work "a blueprint for inner-city renewal on an international scale."

Reg Ward, chief executive of the LDDC, is skeptical about calling docklands a blueprint. He believes that the key to success in urban renewal lies in exploiting an area's unique assets. Where others saw a virtual wasteland, for example, Ward and his coworkers saw 5,000 acres of land along seven miles of water just two miles from the heart of a crowded city. The LDDC also found that docklands is the most interference-free site in London. Thus, the former port may become Britain's first teleport, handling information instead of goods. The area is now linked to the financial district by a network of fiber-optic cables, and the carriers British Telecom and Mercury are building earth-satellite stations for high-capacity transmission of voice, data, and pictures. Britain's major independent TV studio, Limehouse Studios, is ensconced in a renovated banana warehouse. News International, the *Daily Telegraph*, and Associated Newspapers are also moving their printing operations to the docks, to be followed by computer companies and other high-technology businesses. Finally, the LDDC made the imaginative decision to develop the Royal Docks—an awkward area six miles from London—as an airport for "short takeoff and landing" planes. This "STOLport" will provide a direct link with Europe.

According to Ward, docklands' biggest drawback was its inaccessibility. In addition to repairing roads and initiating bus service, the LDDC and the London Regional Transport have received public funds to build a £77 million advanced light-rail system that will connect docklands to London's Underground. The trains will run from the Tower and Greenwich, attracting tourists as well as residents and commuters, and at times passing 24 feet above the water on an old viaduct.

Controversial Claims

The LDDC's claims of success are not universally accepted. Doreen Massey of the Greater London Enterprise Board (GLEB), an economic development agency set up in 1983, believes that Britain's several dozen EZs have not created new jobs but have simply moved them from one area to another. And John Palmer, the GLEB's director of information, notes that even if we assume that the government *has* created jobs in docklands, the average cost of creating each one—in direct expenditures and tax breaks—is about £68,000. He says that the GLEB has created 3,000 new jobs at an average cost of £4,000 each by investing in companies.

LDDC workers agree that some of the jobs in the docklands EZ would have existed elsewhere in London, but they argue that such relocation can be beneficial: the LDDC is bringing economic activity to a depressed area that should last well beyond the lifetime of the development company and the tax holiday. And many businesses—especially small ones—have expanded upon moving to docklands.

The area's borough councils have actively opposed the LDDC's undertakings, arguing that they could spend the allocated money better, and that an agency should not be allowed to usurp power from elected officials. They worry about traffic problems and noise from the proposed STOLport, and both the councils and action groups of residents oppose the construction of luxury housing that locals can't afford and the creation of high-tech jobs that they can't fill.

Ward believes that the corporation's successes will eventually win over local opposition. Many previous tenants of subsidized housing are rushing to put down payments on new homes, and the area's residents are already benefiting from the new bus service, better roads, and two "superstores." In Ward's view, two years from now, the LDDC, the residents, and their borough councils will be cooperating closely to bring further life to docklands.—*Nancy Stauffer* □

A New Launch Toward an SST

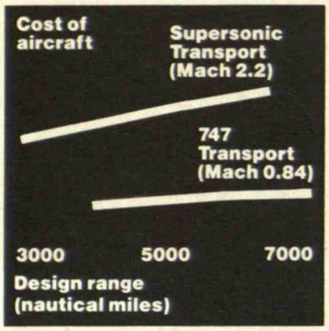
The U.S. aerospace community is poised for a renewed assault on the summit from which it was repulsed a decade ago—a made-in-U.S.A. supersonic transport.

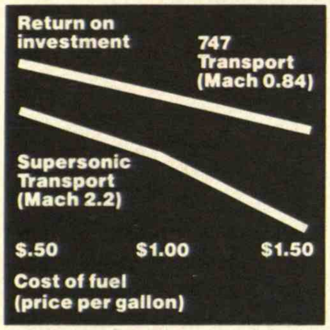
George A. Keyworth II, White House science adviser, is among the believers. He foresees by the year 2000 a 600-passenger supersonic transport (SST) with a speed of up to Mach 3.2, a range of 5,500 miles, and over three times the fuel efficiency of current supersonic aircraft. He bases his optimism on a report on R&D goals in aeronautics released by his Office of Science and Technology Policy (OSTP) early in the spring.

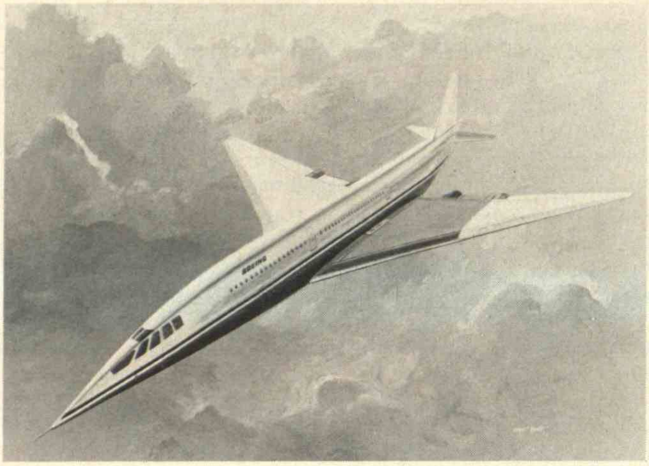
About the same time that the OSTP report was issued, a workshop sponsored by the National Research Council on aeronautical technology predicted that the United States could develop an SST that would be competitive with subsonic airplanes in terms of both capital and operating costs.

Panelists discussing a future SST during the annual meeting of the American Institute of Aeronautics and Astronautics (AIAA) in April were less adventuresome in their predictions: by the year 2000, a two-engine, 250-passenger SST could be flying the 5,500 miles from Los Angeles to Tokyo in just over three hours—but passengers would be paying a premium fare for their quick trip.

New technology would give the SST envisioned at the







Boeing's 1982 plans for a 480-passenger supersonic transport (above) to travel 2.4 times the speed of sound have now been scaled down to 350 passengers and Mach 2.2.

But the SST's greater capacity than today's 747 would not offset its higher costs, and operating expenses would be highly sensitive to increases in fuel prices.

AIAA meeting twice the range and half the weight of the one that the United States considered manufacturing in the 1970s, promised Richard H. Petersen, director of NASA's Langley Research Center:

☐ Built with new materials and operating at higher temperatures, future engines would have efficiencies of 52 to 55 percent, compared with a 41 percent efficiency for the Concorde, the 100-passenger British/French SST. Future engines could weigh half as much and require half as many parts as the engines that would have powered the American SST proposed in the early seventies.

☐ New structural and skin materials—alloys and composites—not only will be stronger and lighter than today's materials but will retain their strength at higher temperatures. That is important because the skin is heated at supersonic speeds.

☐ Interior furnishings, brakes, and tires can be about a third lighter than those planned for the 1971 SST.

☐ Improved aerodynamics will go a long way toward resolving one big dilemma of earlier SST designers: how to shape a craft for supersonic flight that can also be efficient at subsonic speeds.

Each improvement can have a substantial effect on performance. For example, a mere 1 percent reduction in weight yields a 3.5 percent fuel savings, said Petersen. And since fuel consumption directly affects noise levels, the SST envisioned at the AIAA meeting would operate within today's noise limits for landing and takeoff—unlike the Concorde.

Another environmental issue on which the 1971 SST foundered has been disposed of, too. Most experts now agree, said Petersen, that high-altitude flights by even a large fleet of SSTs would have little effect on the stratospheric ozone that protects the earth from overdoses of sunlight.

However, two roadblocks to a viable SST transport remain unconquered.

One is sonic boom. The shock wave that causes the boom appears intractable—an absolute corollary of supersonic flight. No changes in aerodynamics can muffle it. Even the staunchest advocates admit that any new SST could be flown at supersonic speeds only over oceans and unpopulated land areas.

The other obstacle is money. By Petersen's estimate, an SST for the year 2000 might cost $3 billion to $5 billion to develop. Pat Burgess, vice-president of Rolls Royce, estimates a cost at least double that. Whatever the total, it is clearly beyond the resources of any single aerospace company, and it is probably more than any one country can put together. A worldwide consortium, for which there is no precedent, would be required.

Furthermore, once developed, any SST would likely be three times as expensive to build as today's 747, the wide-bodied jet that is the world's most efficient transport, estimates Philip Bandow of Boeing. Yet the SST would handle only twice the volume of passengers. To make up the difference, thinks Bandow, SST flights would have to be priced higher than subsonic service, as are Concorde flights over the North Atlantic today.

With tickets selling at four times the economy New York-to-London fare, Concorde has captured 5 percent of the market. This service, together with Concorde's charter business and the publicity and feeder sales it generates, make British Airways more profitable than it would be without an SST, said Willis D. Lowe, manager of the Concorde fleet. But then Lowe's optimism ran out: the North Atlantic is by far the most popular international route, he told the AIAA: "I simply can't find routes that in the next 25 years will justify the addition of 50 SSTs."

Such pessimism does not sit well with Secor D. Browne, chairman of the Flight Safety Foundation. "No advanced SST will ever fly without more positive attitudes than we've heard today," he told the AIAA at the end of its symposium. He wants to press ahead: the demand for transportation is fast-growing, and during the last years of this century it will grow fastest of all in the Pacific Basin, where a 5,000-mile-range SST would provide nonstop intercontinental service.

In the long run, time is on the SST's side. The technology of subsonic aircraft is mature; new technology will benefit the SST more than competitors that fly slower than sound. Our children—or theirs—may yet find a supersonic bargain in their airline guides.—*John I. Mattill* ☐

DIAGRAMS: OMNIGRAPHICS; PHOTO: BOEING

Little Slips and Big Disasters

In 1854 during the battle of Balaclava in the Crimean War, Captain Nolan of the Light Brigade had a panoramic view of the battlefield, yet he directed his cavalry to almost certain destruction in a valley.

□ In 1895 the ships of the British Mediterranean fleet were sailing in parallel lines only 1,200 yards apart when Admiral Tyron ordered them to reverse direction by turning inward. The two leading ships would have had to be more than 1,600 yards apart to do this. They collided, and 365 lives were lost.

□ In 1975 at Moorgate Station in the London tube, Motorman Newson drove his train into a dead-end tunnel at 35 miles an hour, killing 42 people.

Such horrendous accidents practically demand explanations that the perpetrators were irrational. Official investigators judged Captain Nolan crazy, Admiral Tyron drunk or crazy, and Motorman Newson a suicide. But such conclusions are often wrong, says James Reason, professor of psychology at the University of Manchester in England. Catastrophic errors are psychologically like everyday, absentminded slips—only the consequences are different.

Absentminded slips tend to happen when you are performing almost automatic routines amid familiar surroundings, and are diverted by preoccupations or distractions. "Intrusion errors" occur when you are intending to perform a habitual sequence of actions, such as taking the route to a friend's house, but are diverted and start following some other familiar sequence of actions, such as taking the route to work. In "place-losing errors," you are interrupted in an almost automatic sequence of actions and make a mistake. In "interference errors" you inappropriately blend routines—for example, by saying "absotively" (from "absolutely" and "positively").

Errors often occur when you fail to pay proper attention at branching points—points where you can begin to follow a different routine. And according to the "Law of Errors," Reason writes in the June 1984 issue of *Interdisciplinary Science Reviews*, whenever your thoughts, words, or deeds depart from the course you had intended, they tend to wander in a more familiar direction.

Of course, drunkenness or insanity can lead to mistakes, but investigations suggest that those are the wrong explanations in the case of Motorman Newson. (There is too little evidence to reconstruct what went on in the minds of Captain Nolan and Admiral Tyron.)

Newson had traveled the same route 228 times in the previous two weeks. In fact, he had traveled the route twice earlier that day. But on those trips the lights were on in the Moorgate tunnel; they were off on the third trip. Also, Newson was carrying money to buy a present for his daughter after work. Reason's theory suggests that Nolan was distracted by thoughts about the gift and lulled into a place-losing error. Without the lights that might have alerted him to this error, he continued absentmindedly until he froze in panic at the last moment.

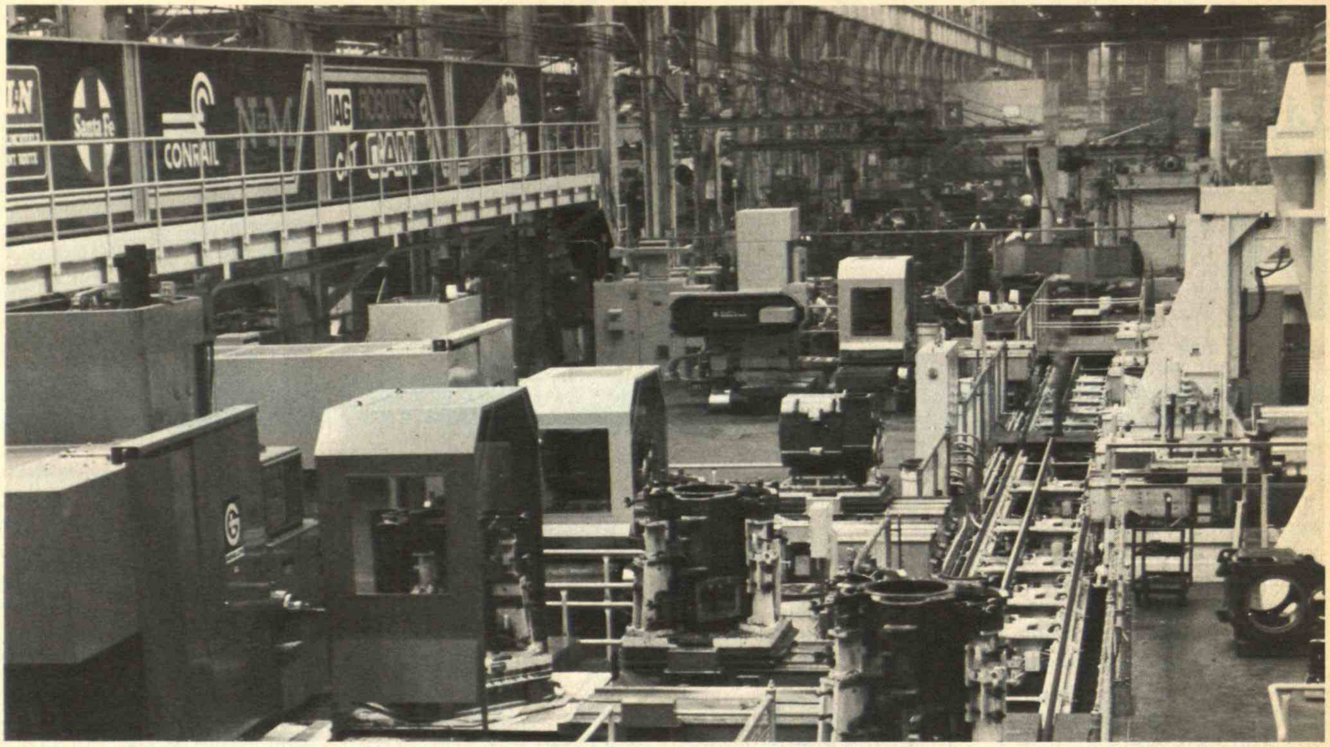
Another disaster that probably resulted from an ordinary slip was the airplane crash in 1977 in Tenerife, the largest of the Canary islands. Captain Van Zanten started the takeoff of his Royal Dutch Airlines 747 after receiving airways clearance but not takeoff clearance. He collided with a Pan Am 747, and 577 people died.

Van Zanten was principally a flight trainer who had not had a scheduled airline flight for 12 weeks and had spent many hours in a flight simulator. There, airways and takeoff clearance are given simultaneously. His flight had been diverted to an unscheduled airfield, and with that additional cause of stress, Van Zanten must have reverted to familiar habits developed on the simulator.

The way to avert catastrophes, says Reason, is to gain a better understanding of how to reduce the likelihood of ordinary human error.—*Richard E. Snow* □

Adapted from European Scientific Notes, *published by the U.S. Office of Naval Research in London.*

ILLUSTRATION: JON MCINTOSH



Flexible Manufacturing, Inflexible Managing

Advocates have set extraordinary goals for flexible manufacturing systems (FMSs), which use computers to schedule production, direct the movement of parts, and control machine tools. Economic theorists such as Harvard's Robert Reich have seen them as a key to revitalizing a U.S. economy having trouble in a rapidly changing and increasingly competitive international marketplace. Martin Rogers, assistant to the secretary of the U.S. Air Force for industrial resources, hopes that FMSs will enable the Defense Department to use the country's industrial base as a "war deterrent": when unexpected shortages of weapons and supplies occur during war, flexible manufacturing systems might readily turn out the parts that are needed.

FMSs may in fact have the potential to make these ambitious visions a reality. Some current systems can produce any of hundreds of different parts on command while increasing productivity threefold. However, unfortunately for U.S. businesses, recent research by Ramchandran Jaikumar, professor at the Harvard Business School, indicates that both Japan and West Germany use FMSs far more flexibly than the U.S.

In Japan, which has about 50 of the world's 100-odd FMSs, the average number of parts produced on a given system is 30; in Germany, with some 20 systems, the average number of parts is almost 85. The 30 or so systems in the United States produce an average of only 8 parts. "FMSs in this country are being managed for short-run increases in productivity rather than to exploit their full flexibility," says Jaikumar.

Marjory Blumenthal, director of a recent study on computer-based automation for the Congressional Office of Technology Assessment, questions whether these comparisons are entirely legitimate. Some of the systems called FMSs in Japan may actually be quite small units known here as machining cells. Also, some of the Japanese and West German FMSs may have been in operation longer than those in the United States, and thus would have had time to produce more parts. However, Blumenthal agrees that foreign FMSs probably are used more flexibly.

Limited use of an FMS's flexibility is not necessarily irrational. For example, John Deere, a farm-equipment manufacturer, bought an FMS to mass-produce several transmission, clutch, and axle housings. Although the company doesn't expect to change these products rapidly, it does plan to produce new models from time to time. Conventional production lines would have to be scrapped, but the FMS can simply be reprogrammed. In effect, says Deere's Bob Shaup, the company bought several lines for the price of one.

However, U.S. managers are neglecting an opportunity to push beyond these uses and exploit FMS flexibility itself, says Jaikumar. U.S. industry primarily uses FMSs as John Deere does—to make long production runs of parts for heavy machinery. But overseas, FMSs are also used to make small runs of precision components, such as for optical and electronic equipment. By using FMSs in industries that develop new products frequently, Jaikumar thinks foreign manufacturers will gain a competitive advantage.

U.S. industry has a growing interest in using FMSs for shorter runs of components in areas such as electronics and hydraulics, says Ivan Johnson, FMS project manager in the Automatic Systems Division at Draper Laboratory. However, most of the systems are still in the planning stage.

Jaikumar also faults U.S.

PHOTO: GENERAL ELECTRIC CO.

GE's computerized flexible machining system (FMS) in Erie, Pa., efficiently shapes motor frames for locomotives. But foreign FMSs often make a much wider variety of parts.

firms for their tendency to buy large "turnkey" systems—complete machine-and-software packages that vendors custom-design for a specific client and sell ready to run. This means that each new FMS is in effect a prototype; manufacturing engineers must work out numerous bugs while under pressure to keep productivity high to justify the large capital investments FMSs require.

By contrast, the Japanese tend to build up FMSs in small, manageable increments. At any given time they might add only one or two computer-controlled machine tools plus a robot to handle the parts, says Jaikumar: "Gradually you get whole factories." Blumenthal notes that many U.S. firms are aware of the problems manufacturers have had with turnkey systems, and are considering building up FMSs module by module as the Japanese do.

Jaikumar also says that Japanese firms are more willing than U.S. firms to invest the time in training people to manage FMSs successfully. Mid-level engineers within the company, protected by lifetime employment, both design and run the systems.

West German firms rely on a different kind of human skill. While U.S. and Japanese firms often install FMSs to reduce their need for shop-floor labor, strong unions have ensured that skilled machinists retain crucial roles in West German systems. Since machinists can readily do the tasks that pose serious problems for automatic systems, such as spotting irregular raw materials and adjusting machines accordingly, or unsnarling the robotic systems that move parts, the machinery and software for the FMS can be simpler. And machinists can also do unanticipated reprogramming on the spot, for instance during transitions from one product to another. "In our rush to automate, we tend to forget that an educated human is still the most versatile problem solver," says Jaikumar.

Reich, who has examined some of these same issues, concurs with Jaikumar's assessment of what U.S. manufacturers must do to become more competitive. "In general, American firms are concerned primarily with improving production efficiencies," says Reich. "Japanese firms worry about improving their problem-solving capacities. Therein lies a world of difference."

So far, few FMSs are in use worldwide, and even when they are used, they generally account for less than 5 percent of the value added to finished products. Thus, says Jaikumar, the "flexibility gap" has hardly produced dire consequences. But if the United States is to use flexibile manufacturing to compete internationally, it has some catching up to do.—*David Kennedy* □

PROFESSIONAL

You're Boxed In

Your career is blocked. You're frustrated and insecure. Time is going by and things aren't getting better.

You need to find a better way. You need new objectives for yourself and new strategies for achieving your objectives.

That's my job. I am a management consultant, specializing in change, and I have helped hundreds get out of that box and onto a more satisfying career and life path.

Call me to explore what I can do for you. There's no charge, no obligation, to explore. Don't wait. Call me now.

Riva Poor, SM Management, MCP from MIT

Private programs. Also 2-day weekend workshops. *(See p. 13 for details.)*

Riva Poor
73 Kirkland Street
Cambridge, MA 02138
Telephone: (617) 868-4447

NELSON, COULSON AND ASSOCIATES, INC.
PROFESSIONAL SERVICING CONSULTANTS

NATIONWIDE OPPORTUNITIES

- Electrical/Electronic Engineers
- Aerospace System Engineers
- Space Communications C^3I
- Guidance & Controls Engineers
- RF/Microwave Engineers
- Software/Hardware Engineers
- Intergrated Logistic Engineers
- Spacecraft Antenna Engineers

Engineers to senior management level, excellent salary, benefits & relocation.

P. R. Coulson, PE, '43
NELSON, COULSON & ASSOC.
P.O. Box 1378
Englewood, CO 80150
303/761-7680

PLACING PROFESSIONALS COAST TO COAST

We are constantly searching for:
•Engineers: EE's, ME's, CHE's•
•Scientists•
•Computer Professionals•
•MBA's•
•Financial Specialists•
•Aerospace Professionals•

Submit your resume and salary history to:
Martin Lyons
Technical Search Inc.
7 No. Main St.
Suite 301
Attleboro, MA 02703
(617) 226-5373

The High-Tech People
Client Companies Assume All Fees

MANAGING EDITOR

for this magazine. Technology Review invites applications for the post of Managing Editor. Familiarity with science and technology and related policy issues is required, together with experience in writing and editing on these subjects and in editorial management. Send resume, writing samples, and comments on this magazine to Editor, Technology Review, Room 10-160, Mass. Institute of Technology, Cambridge MA 02139. An affirmative action/equal opportunity employer.

---

26 years placing engineers
Coast to Coast & All Fee Paid
Electronics-Computers-Communications-Aerospace

Can we help you today?
(800) 523-2906; in PA (215) 735-4908

Arthur L. Krasnow, Pres. (MIT, USNA)
Atomic Personnel, Inc.
Suite T, 1518 Walnut St., Phila., PA 19102

THE ACCESS GROUP, INC. — **Engineering Specialists Nationwide**

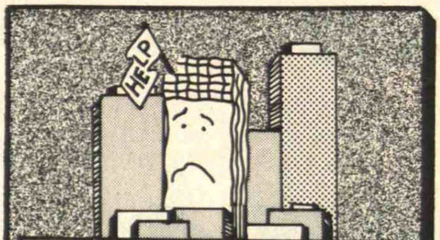
All Levels-All Industries.
ALL FEE PAID-FULLY CONFIDENTIAL.
Contact-Bill Kan, Ph.D. '58,
P.O. Box 3267
Stamford, Ct. 06905. 203-356-1166

THE BEST & BRIGHTEST
Ask P'nB to Market Them Because I'm an Engineer Who Talks Your Language

Was out there myself for 25 years—from Designer to Program Manager.
An IEEE member and MIT engineer, I know what YOU want.
Send your resume, you'll be the client, with all fees and expenses paid by nationwide companies looking for the BEST and the BRIGHTEST.

Marc Cutler, President
(215) 687-4056 day or night

P'nB CONSULTANTS
Box 494-T, Wayne, PA 19087
Known Coast to Coast



Building Problems?

35 years experience in Industrial, Commercial and Institutional Construction. Our services could remove a few headaches and pay for themselves many times over. Call or write now for a free review of your program or problems.

Robert F. Rowe '48
Construction Consultant
Control Data Business & Technology Center
Suite I-532
701 East Bay Street
Charleston, SC 29403
(803) 722-8610

SECRETARY, MIT ALUMNI ASSOCIATION

The MIT Alumni Association is seeking an MIT alumnus or alumna with significant management experience preferably in Sales Marketing, alumni or fundraising experience. The position reports to the Executive Vice President, the Association's senior staff member, and involves the management of a diverse group of professional and support people. The work involves direct contact with alumni volunteers in programmatic and fundraising roles. Please send a resume to ***William J. Hecht '61, Executive Vice President, MIT Alumni Association, Room 10-110, Cambridge, MA 02139.***

MISCELLANEOUS

Ideas, inventions, wanted! Industry presentation/national exposition. 1-800-528-6050. X831.

Satellite Systems Sale & Ser. Complete systems with 10′ dish $1295. For info & pricelist $1 & SASE POBOX 2343 Corsicana, TX 75110.

OIL & GAS SOFTWARE
for the serious personal investor or fiduciary. Management Information at YOUR fingertips. Written by investors for investors.
Oil & Gas Systems, P.O. Box 125-TR, Abington, PA 19001-0125, (215) 887-4989

THE CULINARY COMPUTER™
and the US's top radio/TV food critic provide private, reliable metro-NY dining advice. 10 pages of tersely-written reviews. 24+ top restaurants computer selected from a data base of 15,000+ reviews. Unique indexing scheme allows customized filing. Wine charts, travel diets, etc. $27 for 12 information-packed issues. Money-back guarantee.
BOB LAPE's DINING GUIDE
Dept. TR, Box 11011, Greenwich, Ct. 06830

UNIVERSITY DEGREES WITHOUT CLASSES

Bachelor's, Master's, Doctorates. Accredited, economical, accelerated. Credit for technical knowledge and work experience. Write: Dr. John Bear, P.O. Box 11447-TR1, Marina del Rey, CA 90295

VISITOR ACCOMMODATIONS

ubb UNIVERSITY BED AND BREAKFAST, LTD.

Looking for alternatives to expensive hotels?
We have rooms in Greater Boston, close to public transportation, for visiting professionals. Breakfast too!

Call (617) 738-1424 Host inquiries welcome.

CLASSIFIED ADS: $17.00 per line, three line minimum. (Allow 28 letters & spaces for first line, 50 letters & spaces for each additional line.)
DISPLAY ADS: $70.00 per inch, 3 inch maximum.
COPY DEADLINE: Five weeks prior to publication date. Payment in advance of insertion required. Send orders to Classified Section, Technology Review MIT 10-140, Cambridge, Mass. 02139.

GIVE HER A DIAMOND TO SET HER WORLD ON FIRE.

De Beers

The necklace shown features a quality diamond of 2.02 carats.

Every quality diamond of a carat or more is one of nature's rarest and most exquisite phenomena. Each is a visible reflection of you. Unique in all the world, possessing four vital qualities that set it apart forever. They are called the 4C's: Cut, Color, Clarity and Carat-weight. It is the 4C characteristics that determine the value of a diamond—and to an astonishing degree the beauty and value of your jewelry—no matter what the design.

Your jeweler is the expert where diamonds are concerned. His knowledge can help make the acquisition of a quality diamond of a carat or more the beautiful, rewarding experience it should be.

Give her a quality diamond of a carat or more. A truly rare and beautiful gift. Like the woman you love.

A diamond is forever.

A QUALITY DIAMOND OF A CARAT OR MORE.
A FIRE RARELY SEEN.

© Eastman Kodak Company, 1985
200 mm at 1/60 sec at f/32